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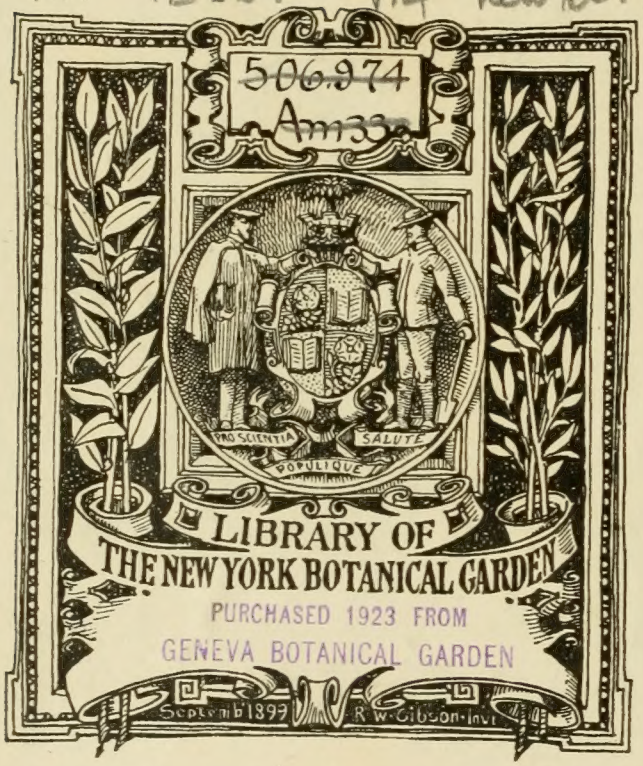

MEMOIRS

OF THE

AMERICAN ACADEMY

OF

ARTS AND SCIENCES.

NEW SERIES.

VOL. IV.—PART I.

CAMBRIDGE AND BOSTON:

METCALF AND COMPANY,

PRINTERS TO THE UNIVERSITY.

1849.

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MEMOIRS

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AMERICAN ACADEMY.

I.

PLANTÆ FENDLERIANÆ NOVI-MEXICANÆ: *An Account of a Collection of Plants made chiefly in the Vicinity of Santa Fé, New Mexico, by* AUGUSTUS FENDLER; *with Descriptions of the New Species, Critical Remarks, and Characters of other undescribed or little known Plants from surrounding Regions.*

BY ASA GRAY, M. D.

(*Communicated to the Academy, November 8th*, 1848.)

DESIROUS to render the occupation of New Mexico by the United States troops subservient to the advancement of science, and to make known the vegetation of a region which had scarcely been visited by a naturalist, Dr. Engelmann and myself, with the coöperation of one or two friends who patronized the enterprise, induced Mr. Fendler to undertake a botanical exploration of the country around Santa Fé. In execution of this plan, Mr. Fendler left Fort Leavenworth, on the Missouri, on the 10th of August, 1846, with a military train, he having been allowed by the Secretary of War a free transportation for himself, his luggage, and collections. The following account of his route, and brief indication of the physical features of the country, I copy from a sketch which Dr. Engelmann has kindly furnished.*

* Further information of interest, as to the character and features of the country, may be found in Dr. Wislizenus's *Memoir of a Tour to Northern Mexico, in* 1846 *and* 1847, with excellent maps, profile-elevations, &c., printed by the U. S. Senate; in Lieut. Abert's *Report of an Expedition on the Upper Arkansas and through the Country of the Camanche Indians*, &c.; and also, doubtless, in Lieut. Emory's Report, — of which unfortunately, I have not been able to procure a copy.

"Mr. Fendler travelled the well-beaten track of the Santa Fé traders to the Arkansas, and then followed that river up to Bent's Fort, which he reached on the 5th of September. On the 25th of September the Arkansas was crossed, four miles above Bent's Fort, and the westerly course was now changed to a southwestern direction. *Opuntia arborescens* was first observed in the barren region now traversed; and the shrubby Atriplex (No. 709) was the most characteristic and abundant plant, furnishing almost the only fuel to be obtained. Thus far the country was a comparatively level, or rather rolling, prairie, rising gradually from one thousand to more than four thousand feet. But on September 27th, the base of the mountain chain was reached, which is an outlier of the Rocky Mountains, and attains in the Raton Mountains the elevation of eight thousand feet. West of these, in dim distance, the still higher Spanish Peaks appear, which have only been visited, very cursorily, by the naturalists of Major Long's expedition in 1820. Scattered pine-trees are here seen for the first time on the Rio de los Animos (or Purgatory River of the Anglo-Americans), which issues from the Raton Mountains. The party several times crossed large perfectly level tracts, which at this season, at least, showed not a sign of vegetation; in other localities of the same description, nothing but a decumbent species of Opuntia was observed. The sides of the Raton Mountains were studded with the tall *Pinus brachyptera*, Engelm. (831), and the elegant *Pinus concolor* (828). Descending the mountains, the road led along their southeastern base, across the head-waters of the Canadian.

"On the 11th of October, Mr. Fendler obtained the first view of the valley of Santa Fé, and was disagreeably surprised by the apparent sterility of the region where his researches were to commence in the following season. The mountains rise probably to near nine thousand feet above the sea-level, two thousand feet above the town, but do not reach the line of perpetual snow, and are destitute, therefore, of strictly alpine plants. Their sides are studded with the two Pines already mentioned, with *Pinus flexilis*, &c.

"The Rio del Norte, twenty-five or thirty miles west from Santa Fé, is probably two thousand feet lower than the town, and spring opens earlier there; but its peculiar flora is meagre. On its sandy banks a few interesting plants were obtained; and some others in places where black basaltic rocks rise abruptly from the river, or where a rocky talus lies at their base.

"South and southwest of Santa Fé, a sterile, almost level plain extends for fifteen miles, which offers few resources to the botanist. *Opuntia clavata* was found exclusively here; besides this, *Opuntia arborescens*, *O. phæacantha*, *Cereus coccineus*, some grasses, and in some localities the *Shrub Cedar* (834), are the only plants seen on these wide plains. To the west and northwest of Santa Fé, a range of gravelly hills thinly covered with Cedar and the Nut-pine (830) offers a good botanizing ground in early spring. The valleys between these hills appear to have a fertile soil, but cannot be cultivated for want of irrigation. They furnished some very interesting portions of Mr. Fendler's collection, and of Cactaceæ, the *Mammilaria papyracantha*, *Cereus viridiflorus*, *C. triglochidiatus*, and *C. Fendleri*.

"By far the richest and most interesting region about Santa Fé for the botanist, as will be seen from the localities cited in the following systematic enumeration, is the valley of the Rio Chiquito (*little creek*) or Santa Fé Creek. It takes its origin about sixteen or eighteen miles

northeast of the town, from a small mountain lake or pond, runs through a narrow, chasm-like valley, which widens about three miles from Santa Fé, and opens into the plain just where the town is built. Below, the water of the creek is almost entirely absorbed by the numerous irrigating ditches, which are most essential for the fertilization of the else sterile fields. Most of the characteristic plants of the upper part of the creek and of the mountain-sides are those of the Rocky Mountains, or of allied forms; some of which, such as *Atragene Ochotensis* or *alpina*, *Draba aurea*, &c., have never before been met with in so low a latitude (under 36°).

"Mr. Fendler made his principal collections from the beginning of April to the beginning of August, 1847, in the region just described. At that time, unforeseen obstacles obliged him to leave the field of his successful researches. He quitted Santa Fé, August 9th, followed the usual road to Fort Leavenworth, which separates from the 'Bent's Fort road' at the Mora River, and unites with it again at the 'Crossing of the Arkansas.' The first part of the route from Santa Fé to Vegas leads through a mountainous, wooded country, of much botanical interest, crossing the water-courses of the Pecos, Ojo de Bernal, and Gallinas. From Vegas the road leads northeastwardly through an open prairie country, occasionally varied with higher hills, as far as the Round Mound (6,655 feet high, according to Dr. Wislizenus). The principal water-courses on this part of the route, all of which furnished different remarkable species, were the Mora, Ocaté, Colorado (the head of the Canadian), and Rock Creek, all of which empty into the Canadian. Rabbit's Ear Creek and McNees Creek (the head-waters of the north fork of the Canadian) are east of the mountains altogether. From thence the Cimarron was reached, where the Cold Spring, Upper, Middle, and Lower Spring, and Sand Creek are interesting localities. On September 4th, Mr. Fendler recrossed the Arkansas, and reached Fort Leavenworth on the 24th of that month."

Mr. Fendler is about to revisit New Mexico, for a more thorough exploration of the botany of that little known region, and especially of the higher mountains in the northern and western part of the district. It is greatly to be wished that he should receive patronage, in the form of additional subscriptions for his collections, which may enable him to reëngage in this arduous undertaking under more favorable circumstances than before.

Several families of the ensuing enumeration, such as the Cactaceæ, Cuscutineæ, Asclepiadeæ, Euphorbiaceæ, &c., have been elaborated by Dr. Engelmann, of St. Louis, upon whom a large share of the labor and care incident to this enterprise has fallen. His name is affixed to the portions, as well as to various notes, thus contributed by him.

The species of which there were not sufficient specimens collected for distribution in the sets are designated by the sign (†) prefixed to the number. *Vide* No. †2 *et seq.*

RANUNCULACEÆ.

1. Clematis ligusticifolia, *Nutt.! in Torr. & Gray, Fl. N. Am.* 1. *p.* 9. Flowering specimens of both sexes, gathered at Santa Fé, July, and on the Mora River, August; in bottom land, near the water. Likewise at Rio de los Animos, between

Bent's Fort and Santa Fé. There are also fruiting specimens, gathered between the middle of August and January. — The specimens have larger and smoother foliage than the original ones of Nuttall. The leaves are all 5–7-foliolate.

†2. C. Pitcheri, *Torr. & Gray, Fl. N. Am.* 1. *p.* 10. Council Grove, August. — The styles are entirely glabrous in flower, but become more or less pubescent in fruit. The species extends northeastward to Illinois, where it was gathered by Dr. Mead.

3. Atragene Ochotensis, *Pall. Fl. Ross.* 2. *p.* 69; *DC. Prodr.* 1. *p.* 10. Sides and base of steep rocks, in shady places near the creek, Santa Fé; climbing over shrubs. Gathered in flower from May 12 to June 3. — It is singular that this species should have been for the first time detected in the New World at a point so far south. The foliage, &c., is just as in A. alpina, of which it is most probably a mere variety, as Schlechtendal has suggested in respect to the plant from Kamtschatka. But the staminodia are linear, at first scarcely longer than the ordinary stamens, and are all manifestly antheriferous; at length they become a little dilated upwards, and acute or apiculate. How slight dependence is to be placed upon the form of these organs, however, has been shown by Ledebour (*Fl. Alt.* 2. *p.* 378), when justly reducing A. Sibirica to A. alpina. Specimens gathered by myself at Ischl, in Upper Austria, exhibit them strongly emarginate. Nor are they uniformly acute in A. Americana, but oftener spatulate and obtuse, as delineated in *Genera Fl. Amer. Bor.-Orientalis Illustrata*, *t.* 1.

4. Anemone cylindrica, *Gray.* Shady places in a mountain valley a few miles east of Santa Fé; flowering in June. — This species often flowers after the manner of A. Virginiana, developing involucels and secondary peduncles. It should doubtless be referred to De Candolle's section *Anemospermos.*

5. Pulsatilla patens, *Mill.; Torr. & Gray, Fl. l. c.* Mountains, east of Santa Fé.

†6. Caltha leptosepala, *DC.; Hook. Fl. Bor.-Am.* 1. *p.* 22. *t.* 10. Sunny margin of the creek, six miles above Santa Fé, in the mountains. — There are only one or two specimens; and they agree with the plant gathered by Dr. James, in having more oblong leaves than in Hooker's figure, with so acute a sinus as to appear almost sagittate.

7. Ranunculus tridentatus, *H. B. K. Nov. Gen. & Sp.* 5. *p.* 42; *Benth.! Pl. Hartw. no.* 1. Wet places, forming large patches by sending off runners in all directions. — Closely resembling R. cymbalaria, *Pursh*, but larger in all its parts: the flowers are as large as those of R. salsuginosus, and 9–12-petalous in all my specimens.

8. R. affinis, *R. Br.* Var. *β. Hook. Fl. Bor.-Am.* 1. *p.* 13. *t.* 6, *A.* Moist places, Santa Fé; April to June. — The primordial radical leaves are barely crenate-toothed; the others 3–5-parted or lobed. Carpels pubescent, in cylindrical-oblong heads.

9. Aquilegia Canadensis, *Linn.* Rocks in a mountain valley, near Santa Fé. A dwarf form, with more slender spurs than usual: but I observe no other difference.

† 10. Delphinium azureum, *Michx.* Between Bent's Fort and Santa Fé; in bottoms.

11. D. azureum, var. with greenish blue flowers. Banks of the Mora River.

12. Actæa rubra, *Willd.* Damp, shady places in the mountains around Santa Fé.

✓ 13. Thalictrum Fendleri (*Engelm. Mss.*): dioicum; foliis petiolatis; petiolulis primariis brachiatis vel refractis stipellatis; foliolis cordato-rotundatis trilobis; filamentis apice vix incrassatis; antheris setigero-mucronatis; carpellis sessilibus oblique ovatis complanatis costatis carinato-alatis stylo recurvo triplo longioribus; cæt. fere T. Cornuti. — With the last. (T. Cornuti, of which a few specimens gathered on the Mora River were distributed with this species, has the fruit terete, with the prominent ribs all equal.)

BERBERIDACEÆ.

✓ 14. Berberis (Mahonia) Aquifolium, *Pursh, Fl.* 1. *p.* 219. *t.* 4. Mountains; upper part of Santa Fé Creek. "Calyx 6-bracteolate." *Engelm.*

✓ 15. Berberis Fendleri (sp. nov.): nitidissima; ramis vernicosis; spinis 3–5-partitis; foliis oblanceolatis oblongisve muticis subintegerrimis utrinque lucidis; racemis pendulis densifloris folia multo excedentibus; bracteolis calyculi sepalis dimidio brevioribus; petalis acutiusculis; baccis immaturis subglobosis 2–3-spermis. — Santa Fé Creek, at the foot of steep and rocky banks, near the water. Shrubs three to four feet high, flowering at the end of May. — A beautiful and very distinct species, allied to B. Canadensis; but with the numerous and crowded golden flowers fully as large as those of B. vulgaris: the conspicuous calyculate bractlets tinged with red or pink. Branches brown, remarkably smooth and shining, as if varnished. The leaves are also lucid; those of the clusters from 6 to 18 lines long, and quite entire, or with few obsolete teeth; but the cauline appear to be sparingly spinulose-serrate.

PAPAVERACEÆ.

✓ 16. Argemone hispida (sp. nov.): radice perenni; caule crasso foliisque profunde pinnatifidis pube brevi cinerea undique tectis et (nervis marginibusque præsertim) setosissimis; calyce aculeato; corolla alba maxima; capsula cylindrica (2-unciali) acutata spinis validis setisque horrida. — Low, sandy places around Santa Fé; the stems 1 to 2 feet high, growing socially in great numbers; June, July. (Also on the Upper Arkansas, &c., *Fremont, Wislizenus.*) — The flower is 3 or 4 inches in diameter, and accords with Dr. Lindley's figure of A. grandiflora, excepting the prickly calyx. That is a glabrous plant, while ours is not only densely setose, but is hoary throughout with a short and close hirsute pubescence. The pod is covered with very strong spines, of which the larger are often branched, and also with smaller prickles and a hoary and bristly pubescence. A. Mexicana was also collected, in two forms.

FUMARIACEÆ.

17. CORYDALIS AUREA, *Willd.*; *Torr. & Gray, Fl.* 1. *p.* 63: var. (C. montana, *Engelm. Mss.*) siliquis undique vel ad suturas tantum pruinoso-puberulis. — Rocks, Santa Fé Creek; April to July; with fine golden-yellow flowers, as in the plant from Northern New York and Vermont, and, like it, biennial. The pruinosity of the pod is variable, and sometimes slight; so that I cannot consider the plant as a distinct species.

CRUCIFERÆ.

18. NASTURTIUM SINUATUM, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 73. Low, sandy banks washed by the water, from the Mora River to the Rio del Norte. — The specimens accord well with Nuttall's character, but have no ripe fruit. Specimens gathered in Missouri by Dr. Engelmann have linear and arcuate siliques, as long as their pedicels.

19. N. OBTUSUM, *Nutt. l. c.* Low, wet places along Santa Fé Creek. — One of the minute-flowered species, of diffuse habit. The divisions of the leaves are much less toothed than in specimens from the Mississippi River, &c. In this, as in other species of the genus, the siliques vary in length and shape; some specimens being barely oblong, and, in a form gathered in Texas by Mr. Wright, even short oval; thus bearing the same relation to the type of the species that the next does to the genuine N. palustre.

20. N. PALUSTRE, *DC. Syst.* 2. *p.* 191: var. siliculis turgide ovoideis; caule foliisque inferne hirtis. Santa Fé Creek. — This is just the common species of the Northern States, which passes for the N. palustre (cf. *Gray, Man. Bot. N. U. S. p.* 32); but it has much shorter pods than the true plant of that name, into which, nevertheless, it appears to merge by numerous gradations. A more hairy form, with remarkably small and ovate pods, is N. hispidum, *DC.* The only *characteristic* North American specimens of N. palustre which I possess were collected by Dr. Sartwell in Western New York.

21. N. SPHÆROCARPUM (sp. nov.): glabrum; caule erecto seu decumbente; foliis oblongis obtusis lyrato-pinnatifidis vel incisis obtuse dentatis (ramealibus subintegerrimis) petiolatis, petiolo anguste marginato basi pl. m. auriculato; racemis paniculatis; floribus minutis; petalis albis spatulatis calycem subæquantibus; siliculis globosis (vix lineam longis) parvis stylo brevi apiculatis pedicello paulo brevioribus. — Low places along Santa Fé Creek. — Allied apparently to N. globosum and N. Camelinæ, *Fisch. & Mey.*; which, with N. Austriacum, N. amphibium, &c., are ambiguous between this genus and Cochlearia or Armoracia, to which they are by some authors referred.

22. STREPTANTHUS LONGIFOLIUS, *Benth.! Pl. Hartw. no.* 52. *p.* 10. At the foot of the mountains on Santa Fé Creek; July, August. — The half-grown pods are pendulous. Lower leaves rough-hirsute, lanceolate, more or less toothed, the radical strongly so.

23. S. MICRANTHUS (sp. nov.): caule gracili inferne scabro superne glaberrimo paniculato; foliis anguste linearibus integerrimis scabris (in sicco falcato-contortis); racemis gracillimis laxis; floribus pusillis erectis; petalis lineari-spathulatis (roseo-albidis) calycem laxum purpureo modice tinctum) paulo excedentibus; filamentis liberis inclusis; siliquis filiformibus teretis appresso-erectis; seminibus immarginatis. — Margins of Santa Fé Creek; July. — The smallest-flowered species of the genus. Allied to the preceding; but the flowers only a line long, and the siliques in all stages strictly erect. These are small in proportion, 1½ inch long at most, scarcely thicker than sewing-thread, and quite terete. Stem two feet high; the slender leaves one to two inches long, the upper nearly filiform.

24. S. LINEARIFOLIUS (sp. nov.): glaberrimus; caule erecto apice paniculato; foliis linearibus vel inferioribus lanceolatis acutatis integerrimis basi attenuatis sessilibus rigidiusculis subglaucis; petalis obovatis (roseo-purpureis), unguibus calyce laxo subduplo longioribus; siliquis (immaturis) erectis filiformibus teretiusculis (2½ unc. longis) stylo brevissimo apiculatis; seminibus immarginatis oblongis. — Mountainous regions from Santa Fé to Vegas, on sunny rocks; July, Aug. — Plant a foot or more in height, from an annual or biennial root, often branched from the base. Leaves 1½ to 2½ inches long, pale, rigid, all tapering to a narrow base; the radical wanting. Sepals turning purplish. Petals half an inch long, or less. Valves of the narrow silique carinate – one-nerved.

25. ARABIS HIRSUTA, *Scop.* Santa Fé Creek, &c. June, July.

†26. TURRITIS GLABRA, *Linn.* With the last.

27. T. PATULA, *Graham! in Edinb. New Phil. Jour.; Hook! Fl. Bor.-Am.* 1. *p.* 40. — Moist, sandy soil and on rocks, Santa Fé Creek; March to May. — Flowers white, usually tinged with rose-color, rather smaller than in the original specimens.*

* T. retrofracta, *Hook.* (which, according to a Greenland specimen from Prof. Vahl, is Arabis Holbollii, *Fl. Dan.*), has hirsute pedicels, as mentioned by Graham in the original description. We have a variety of this (in flower only), gathered on the Kooskooskee River by the Rev. Mr. Spalding, which has deep purple flowers like a Streptanthus. It is, perhaps, the Streptanthus angustifolius of Nuttall.

There are no well-defined limits between Streptanthus, Arabis, and Turritis. The subjoined is a new Texan species, which might, perhaps, as well be referred to Arabis § Lomaspora as to Streptanthus.

STREPTANTHUS PETIOLARIS (sp. nov.): subglauca; caule elato; foliis omnibus longe petiolatis amplis, radicalibus parce pilosis lyrato-sectis, caulinis glaberrimis inferioribus lyrato-3 – 5-lobatis vel hastatis triangulato-lanceolatis repando-dentatis acuminatis, superioribus lanceolatis plerisque integerrimis; racemo virgato laxifloro; petalis spathulatis albidis et purpureo tinctis calycem erectiusculum virido-purpurescentem subdimidio excedentibus pedicello apice incrassato brevioribus; siliquis lato-linearibus complanatis rectis erectis stylo brevissimo apiculatis; valvis planis venulosis basi tantum uninervatis; seminibus in loculis circ. 20 latissime alatis septo æquilatis; funiculis septo adnatis, parte libera dilatatis. — San Marcos Spring, Texas, *Mr. Charles Wright;* May. Also raised in the Botanic Garden from seeds which flowered as an annual in September. — Whole plant glabrous, except the base of the stem and the lowest leaves. Stems 2 or 3 feet

28. CARDAMINE CORDIFOLIA (sp. nov.): caule erecto simplici e rhizomate fibrilloso repente basi piloso usque ad apicem folioso; foliis omnibus petiolatis cordatis parce repando-dentatis angulatisve ciliatis, infimis rotundatis, superioribus triangulato-cordatis subacuminatis; floribus majusculis albis; siliquis immaturis erectis pedicello duplo longioribus. — Margin of Santa Fé Creek, in the mountains; May, June. — A species nearly allied to C. rhomboidea, C. rotundifolia, and C. asarifolia; distinguished from the first by having numerous cauline leaves which are all cordate and petioled, and by its shorter fructiferous pedicels; and from the second by the stouter stems, the cordate, acute, and ciliate upper leaves, thickish pedicels, larger flowers, &c. It appears to be stoloniferous from the base. The foliage is more like that of C. asarifolia; but the leaves are not reniform, or rounded except the lowest, and are 1½ to 2½ inches long.

29 – 31. SISYMBRIUM INCISUM (*Engelm. Mss.*): "annuum vel bienne; caule glabriusculo seu puberulo seu glanduloso-piloso; foliis pinnatisectis, segmentis lanceolatis vel lineari-lanceolatis inciso-serratis; petalis flavis lanceolato-spathulatis calycem superantibus; pedicellis calyce ter-quaterve longioribus, fructiferis (racemo fructifero elongato) patentibus capillaribus siliquas lineari-filiformes erecto-patentes subæquantibus; valvis indistincte uninerviis." — Banks of streams in New Mexico; Santa Fé Creek and Mora River; June to August. Plant 1 to 2 feet high, branching, at length almost glabrous. Silique about 5 lines long; the valves with one indistinct middle nerve. Seeds linear-oblong, yellow, almost smooth, in one row. — Distinguished from S. Sophia by the longer petals, shorter silique on proportionally longer pedicels, and coarser, much less divided leaves. No. 29 and No. 31 are forms with large leaves, their lanceolate segments coarsely serrate or incised. No. 30 is a very imperfect and dubious specimen. — From Clear Water, Oregon, by Mr. Spalding, I have another form (β. FILIPES) of the same species, with the divisions of the cauline leaves narrowly linear, sparingly incised or incisely pinnatifid, or some of them quite entire, and with fructiferous pedicels three fourths of an inch long and longer than the pods. The species would appear to stand between S. Sophia and S. tanacetifolium, *L.* (Hugueninia, *Reichenbach*), with which, like its allies, it accords in the barely one-nerved valves of the silique.

32. S. CANESCENS, *Nutt. Gen.* 2. *p.* 68. Dry hills around Santa Fé. Valves of the silique only one-nerved, as in Hugueninia; but the seeds more or less 2-seriate.

high, mostly simple. Leaves from 3 to 7 inches long, and with petioles of about half their length; the lower with a hastate-lanceolate or triangular outline; the upper broadly lanceolate with a truncate, rounded, or often a tapering base. Flowers two or three lines long. Petals narrowly spatulate, gradually narrowed into a canaliculate barely concave claw. Siliques numerous, in a virgate raceme, three inches long, two lines wide: valves membranaceous; the midnerve distinct at the base, but evanescent below the middle. Septum nerveless; the areolæ oblong, bounded by even lines.

✓ 33. Erysimum asperum, *DC.; Hook. Fl. Bor.-Am.* 1. *p.* 64. *t.* 22. In ripe fruit. — San Miguel to the east of Rock Creek, in patches of fertile and loose soil, on high prairies; August. — Cotyledons incumbent. Siliques spreading.

34. E. asperum, *DC.* With rather small flowers and narrow leaves: yet scarcely agreeing in the length of the petals with E. parviflorum, *Nutt.* — Valley of Santa Fé Creek; May to July.

35. E. asperum, *DC.*, var. A less hoary form, with larger flowers; the young siliques erect. — High on a ledge of rocks overlooking the Rio del Norte; May. — Mr. Nuttall has apparently multiplied the species unduly.

✓ †36. Stanleya pinnatifida, *Nutt.! Gen.* 2. *p.* 71; *Gray, Gen. Ill. t.* 65. — A single specimen was gathered in September, 1846, fifteen miles northeast of Rio de los Animos, between Bent's Fort and New Mexico. It bears nearly full-grown pods, as well as flowers, although all the lower part of the dense racemes have been unfruitful. The upper leaves are linear, and many of them, and even of the lower, are entire or nearly so. Hence it may be S. heterophylla, *Nutt.;* but the lamina of the petals is much shorter than the claws. — Although not mentioned in Hooker's Enumeration of Geyer's collection, I possess a specimen, distributed as No. 97, of what appears to be S. viridiflora, *Nutt.* The thick and smooth leaves are all perfectly entire.

†37. Sinapis nigra, *Linn.* Near irrigating ditches, Santa Fé; June, July. Doubtless introduced.

✓ 38. Vesicaria alpina, *Nutt.! in Torr. & Gray, Fl.* 1. *p.* 102; *Hook.! Lond. Jour. Bot.* 6. *p.* 70. On the lesser hills west of Santa Fé, in pebbly and dry soil, on gently sloping declivities; April to May, and, in fruit, June 7th. — Abundant and fine specimens of this rare species are distributed. The dense, silvery tufts are completely covered with the showy, golden-yellow blossoms. It would be a charming plant for rockwork. In some specimens the style is considerably shorter than the silicle.

†39. V. arctica, *Richards.*, var. *a. Hook. Fl. Bor.-Am.* 1. *p.* 48? Dry, gravelly hills, Santa Fé; May. In flower only.

†40. V. Fendleri (sp. nov.): suffruticosa, nana; caulibus ramosissimis dense foliosis paucifloris; foliis spathulato-linearibus brevibus ($\frac{1}{4}$ – $\frac{1}{2}$ unc. longis) integerrimis argenteo-incanis, infimis rosulatis; siliculis globosis glaberrimis stylo tenuissimo paulo brevioribus. — On the smaller hills around Santa Fé; with No. 38. The single, but very perfect specimen, gathered on the 21 of May, is almost entirely in fruit. The numerous stems are two or three inches high, branched from the base, and the shoots of the year are thickly clothed with the silvery leaves, which are much smaller than in any other species. The flowers are apparently less than half the size of those of V. Ludoviciana, and only

from two to six on each stem; the smooth pods are exactly spherical, about 2 lines in diameter, and on pedicels only one fourth of an inch long.

41. Draba cuneifolia, *Nutt.! in Torr. & Gray, Fl.* 1. *p.* 108. Bed of Santa Fé Creek, in moist and gravelly soil; April and May.*

42. D. micrantha, *Nutt. l. c.* Sunny side of ravines on the Rio del Norte. In fruit; May.

43. D. aurea, *Vahl. Fl. Dan. t.* 1460; *Hook. Bot. Mag. t.* 2934. Shady declivities, along Santa Fé Creek, at the foot of mountains, &c.; May to July. — Exactly the plant figured by Hooker, from seeds gathered by Drummond in the Rocky Mountains: but it is apparently a perennial.

44. Thlaspi cochleariforme, *DC. Syst.* 2. *p.* 331; *Deless. Ic. Select.* 2. *t.* 52. Santa Fé Creek, in the mountains; March to June.

45. Lepidium ruderale, *Linn.* Eastern Mountain range, near Santa Fé.

46. L. alyssoides (sp. nov.): annuum, glabrum; caulibus diffusis corymboso-racemosis; foliis anguste linearibus mucronulatis basi attenuatis integerrimis, infimis nunc pinnato-3–5-lobatis; racemis densis corymbosis; petalis orbiculato-spathulatis calyce triplo longioribus; staminibus 6; siliculis ovatis apteris vix emarginatis glabris; stylo brevissimo. — Mountain valleys, from Santa Fé eastward to Rabbit's Ear Creek; Aug. Also recently collected (in the Rocky Mountains?) by Col. Fremont. — Plant 6 to 12 inches high; the corymbose branches minutely puberulent, terminated by dense racemes of conspicuous pure white flowers as large as those of L. montanum, and somewhat resembling Iberis odorata. Leaves 1½ to 2 inches long, about a line wide, the lowest cauline on the larger specimens two lines wide, and often bearing two or four lateral lobes, otherwise entire. Radical leaves wanting. Silicles a line in length, smaller than those of L. integrifolium and more rhombic-ovate: style thrice the length of the minute emargination.

CAPPARIDACEÆ.

47. Cristatella Jamesii, *Torr. & Gray, Fl.* 1. *p.* 124; *Gray, Gen. Ill. t.* 77. Deep, sandy soil, Cimarron River; Aug.

48. Polanisia trachysperma, *Torr. & Gray, Fl.* 1. *p.* 669; *Gray, Gen. Ill. t.* 79. Rather low places, from the Cimarron River to the Rio Colorado. I have elsewhere remarked, that "the verrucose-roughened surface of the seeds, from which the name was

* The plant named Draba lutea β. longipes by Hooker in Geyer's collection, having minutely hispid silicles, would appear to be a form of D. nemoralis.

taken, is not constant, and is sometimes found in P. graveolens; the flowers also vary greatly in size. The species, however, is perfectly distinguished from P. graveolens by the long style, the more exserted stamens, and the entire absence of a stipe to the ovary and pod. It would seem to accord very well with P. uniglandulosa, except that the flowers are only one fourth the size of those delineated in the original figure of that species by Cavanilles." I now possess the Mexican species, which agrees with the figure of Cavanilles in the size of the flowers, and has proportionally much longer styles and stamens than in our plant. I have cultivated our species for several years, and it proves to be quite handsome, flowering throughout the summer.

49. Cleome (Peritoma, *DC.*) integrifolia, *Torr. & Gray, Fl.* 1. *p.* 122; *Gray, Gen. Ill. t.* 76. Low plains, from the Arkansas to Santa Fé; June to October. A white-flowered variety is also mentioned by Fendler. This would be very ornamental in cultivation. The figure in the *Genera Illustrata* was drawn from a specimen which had nearly done flowering, and gives no idea of the beauty of the species.

VIOLACEÆ.

50. Viola cucullata, *Ait.* Santa Fé Creek; April to June.

51. V. Canadensis, *Linn.* Fertile mountain-sides, Santa Fé Creek; May to July.*

CISTACEÆ.

† 52. Lechea minor, *Lam.* Sixty miles west of Independence, Missouri.

HYPERICACEÆ.

53. Hypericum Scouleri, *Hook.! Fl. Bor.-Am.* 1. *p.* 111. Moist places, Santa Fé Creek bottom; June, July. (Also on the Kooskooskee, *Mr. Spalding.*)

CARYOPHYLLACEÆ.

54. Sagina Linnæi, *Presl, Rel. Hænk.* 2. *p.* 14; *Fenzl! in Ledeb. Fl. Ross.* 1. *p.* 339. (Spergula saginoides, *Linn.*) Valley of Santa Fé Creek; May. — Capsule sometimes 6-valved.

† 55. Drymaria sperguloides (sp. nov.): annua, glabra; caule erecto ramoso; foliis

* To this species Hooker (*Fl. Bor.-Am.*) refers V. Scouleri, *Dougl. Mss.*; but a specimen from herb. Bentham, communicated by Dr. Scouler, is surely the V. glabella, *Nutt.*; as also is No. 602 of Geyer's Oregon collection, named by Hooker V. striata. The petals appear to have been sulphur-color. No. 295 of the same collection (V. orbiculata, *Geyer Mss.*) is certainly neither V. rotundifolia nor V. blanda, but, I suspect, V. sarmentosa of Douglas.

sessilibus lineari-filiformibus carnosulis pseudo-verticillatis internodias æquantibus; cymulis terminalibus laxis paucifloris; pedicellis fructiferis deflexis calyce bracteisque oblongis scariosis duplo longioribus: sepalis ovalibus obtusissimis carnosis vix uninerviis margine latissime scariosis; petalis calyce brevioribus ad medium 4-fidis, laciniis exterioribus multo majoribus; capsula pleiosperma. — Valley of Santa Fé Creek in the mountains, in a plain grazed by cattle and horses. Also between Santa Fé and Pecos: July and August. — Plant a span high, in aspect much like depauperate specimens of Spurry (Spergula arvensis); its flowers and pods about the same size. Style 3-parted. Stipules minute, but distinct, mostly geminate. This and the succeeding differ widely in aspect from the ordinary species of Drymaria, on account of the attenuated and sessile leaves. There is another in Dr. Gregg's Mexican collection, with the aspect of Polycarpon tetraphyllum, and evidently allied to D. holosteoides and D. glauca of Bentham.*

† 56. D. TENELLA (sp. nov.): annua, glabra; caule erecto dichotomo ramisque setaceis; foliis sessilibus internodiis multo brevioribus, radicalibus spathulatis brevissimis, caulinis lineari-setaceis: floribus terminalibus brevissime pedicellatis; bracteis minimis ovatis scariosis; sepalis ovatis obtusiusculis 3-nerviis muticis late scarioso-marginatis petala angusta profunde bifida æquantibus; ovario circa 12-ovulato. — Shady places, in woodland on the mountain region, eight miles west of Las Vegas, New Mexico: August: without fruit. — This is a much slenderer plant than the foregoing (5 inches high), with similar leaves, only they are not fasciculate-whorled, and are mostly far shorter than the almost capillary internodes (of which the lower are 1½ to 2 inches long), and the flowers are less than half the size, borne on erect pedicels about as long as the minute bracts, but shorter than the calyx. The geminate and subulate stipules are very small and fugacious.†

* DRYMARIA POLYCARPOIDES (sp. nov.): annua, glauca, depressa; caulibus e collo pluribus adsurgentibus (2-pollicaribus); foliis ovatis obovatisve basi in petiolum brevem angustatis integerrimis crassis internodia plerumque superantibus; cymulis terminalibus et axillaribus plurifloris bracteatis; floribus pro genere maximis (4–5 lin. longis) pedicellis longioribus; petalis sepala ovata obtusa plana margine late scariosa æquantibus alte bifidis, laciniis oblongis integerrimis; ovario multiovulato. — Valley of Bolson de Mapimi, *Dr. Gregg.* — Stamens 5. Capsule not seen.

† A species nearly allied to this, which was raised from seeds mixed with those of a Mammilaria brought from the mountains of Chihuahua by Dr. Wislizenus, is thus characterized by Dr. Engelmann: —

"DRYMARIA NODOSA (sp. nov.): annua, diffusa, trichotomo ramosissima; ramis basi nodosis tumidis brachiatis; internodiis superne glanduloso-puberulis; stipulis filiformibus; foliis linearibus canaliculatis glabris; floribus in dichotomia ramulorum pedunculatis; sepalis lanceolatis acuminatis trinerviis; petalis ad unguem bipartitis, lobis oblongo-linearibus retusis s. emarginatis calycem superantibus; staminibus 5 disco carnoso quinquelobo insidentibus; ovario breviter stipitato subgloboso pluriovulato; calyce persistente clauso capsulam

60. D. CORDATA, *Willd. ex Rœm. & Schult. Syst. 5. p. 406?* Slender specimens, a little pubescent. A few miles east of Santa Fé; August.

† 57. ARENARIA (EREMOGONE) FENDLERI (sp. nov.): caudice polycephalo; turionibus imbricato-polyphyllis; foliis prælongis erectis setaceis planiusculis margine serrulato-scabris cauleque simplici glabris, caulinis ochreato-connatis; cymis strictis sparsifloris et calycibus glanduloso-pubescentibus; pedicellis gracilibus; sepalis ovato-lanceolatis sensim acuminatis cuspidatis inferne late scariosis medio viridibus trinerviis petala obovata subæquantibus; stylis exsertis. — Prairies, five miles west of Las Vegas; August. — A grassy-leaved species, belonging to a group not before known in the New World, and to the subdivision *Chromolemmæ* of Fenzl. My specimen is eleven inches high, just in flower, but destitute of fruit. The leaves of the sterile radical tufts are 3 to 4 inches long; the cauline pairs (3 or 4) successively shorter. Petals white, 4 lines in length.

58. STELLARIA LANUGINOSA, *Torr. & Gray, Fl.* 1. *p.* 187; — a smoothish variety. Foot of high rocks, two miles east of Mora River; August.

62. S. LANUGINOSA; the ordinary form. Santa Fé Creek, in the mountains; June.

59. MÖHRINGIA UMBROSA, *Fenzl in Ledeb. Fl. Ross.* 1. *p.* 372. Rocky places, at the foot of mountains, Santa Fé Creek; May. — Plant multicipital, with the leaves approximate, smaller in all its parts than the figure of Ledebour in *Icones Pl. Fl. Ross. t.* 322.

61. CERASTIUM NUTANS, *Raf.; Torr. & Gray, Fl.* 1. *p.* 189. Santa Fé Creek, in the mountains; May, June.

63. SILENE MENZIESII, *Hook. Fl. Bor.-Am.* 1. *p.* 90. *t.* 30; *Torr. & Gray, Fl.* 1. *p.* 676; — a small state with narrower leaves (S. stellarioides, *Nutt.*). — Margins of Santa Fé Creek, in the mountains; May, June.

64. S. ANTIRRHINA, *Linn.* Same habitat as the last.

† 65. S. DRUMMONDII, var. (S. multicaule, *Nutt.! in Torr. & Gray, l. c.*) A large state. With the last.

† 66. S. SCOULERI, *Hook. Fl. Bor.-Am.* 1. *p.* 88? var.? Woodlands, six miles west of Las Vegas; August.

duplo breviorem includente; seminibus circa 3 asperis. — Cosiquiriachi, in the State of Chihuahua; fl. in June and July. — About 6 inches high, much branched and diffuse; branches at right angles with the stem. Styles of two shapes, short with minute stigmata, and longer than the ovary with 3 distinct recurved stigmata; both forms on the same plant, and both flowers apparently equally fertile." *Engelm. Mss.* — From this, No. 697 of Coulter's Mexican collection (specimens of which I have received from Prof. Harvey) scarcely differs, except that the plant is less diffuse, the leaves nearly plane, the alar pedicels shorter, and the petals smaller, — differences which are likely to arise from station.

†67. S. STELLATA, *Ait.*; *Torr. & Gray, Fl. l. c.* Near Fort Leavenworth; September.

†68. ANYCHIA DICHOTOMA, *Michx.* West of Independence, Missouri.

69. PARONYCHIA JAMESII, *Torr & Gray, Fl.* 1. *p.* 170. High prairies, in gravelly soil, east of Big Sand Creek (between the crossing of the Arkansas and Bent's Fort), Sept., 1846; and from San Miguel, New Mexico, to Council Grove, Aug. – Sept.

70. P. SESSILIFLORA, *Nutt. Gen.* 1. *p.* 160; *Hook. Fl. Bor.-Am.* 1. *p.* 226. *t.* 75. Near McNees Creek (a tributary of the North fork of the Canadian River); August.

PORTULACACEÆ.

71. TALINUM PARVIFLORUM, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 197. Santa Fé Creek, in the mountains; and between Rabbit's Ear Creek and McNees Creek; July, Aug. Flower lilac. — The capsule is *oval*, and the stamens only *five* in the specimen examined.*

†72. T. CALYCINUM (*Engelm.*): "rhizomate crasso; caulibus demum ramosis; foliis subteretibus elongatis, basi triangulari productis; pedunculis elongatis nudis; cyma bracteosa; sepalis 2 ovato-orbiculatis basi productis cuspidatis persistentibus; petalis fugacibus calycem bis superantibus; staminibus sub-30; stylo elongato [*declinato*]; stigmatibus 3 abbreviatis. — In sandy soil, on the Cimarron River; flowering in June. Differs from T. teretifolium by its larger leaves, larger flowers, much larger and persistent sepals, larger fruit and seed. Leaves 1½ to 2 inches long; flowers 10 to 11 lines in diameter; capsule and seeds twice as large as in T. teretifolium." *Engelm. in Wislizen. Report* (1848), *p.* 88. — Dr. Engelmann, with whom it has now flowered in cultivation, writes that it is quite ornamental, the flowers being even 15 lines in diameter, and that it is further distinguished from T. teretifolium by the style being much exserted beyond the stamens and declined. But the sepals, he remarks, fall away before the capsule ripens. — Fendler's specimens are from the sand-hills, four miles south of the crossing of the Arkansas River; "the flower fine red, of the size of a dime."

†73. PORTULACA PILOSA, *Linn.* Sand-hills of the Arkansas, &c.; Sept. Flower red, nearly the size of a half-dime.

†74. P. OLERACEA, *Linn.* Santa Fé; common in waste places.

* The plant of Geyer's collection named "Claytonia spathulata" by Hooker has the leaves all alternate and linear, and the stem branches repeatedly. It is surely different from the plant figured in the *Flora Bor.-Am. t.* 74, and is the C. dichotoma, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 202. — From the Kooskooskee, by Mr. Spalding, I have large and unusually prolonged specimens of C. exigua, *Torr. & Gray, l. c.*; a plant which, in the *Suppl. to Bot. Beech. Voy.* is referred to C. spathulata; but I think incorrectly, judging from the figure and description of the latter species, of which I have no specimen.

MALVACEÆ.

75. Malva borealis, *Wallmann in Liljebl. Sv. Fl.* sec. *Fries.* (M. rotundifolia (borealis), *Fries, Novit. Fl. Suec. ed. 2. p.* 218; *Koch, Syn. Fl. Germ. p.* 130. M. rotundifolia *β.* pusilla, *Smith, DC.* M. obtusa, *Torr. & Gray! Fl.* 1. *p.* 225.) Waste places, Santa Fé; June to August. — This species, which is well characterized by Fries, Koch, &c., is distinguished from M. rotundifolia, *Linn.*, by the very small corolla, and by the transversely reticulated-rugose carpels, which are margined on the back, where they meet each other by a more or less toothed edge. The calyx-lobes are also broader and larger, especially in fruit, the leaves somewhat less lobed, and, in the New-Mexican and Californian specimens (probably introduced from the Old World) the peduncles are very much shorter, — a point which is not mentioned by European authors. The root is strictly annual, while that of M. rotundifolia appears often to be perennial. Dr. Engelmann and myself have raised the plant from seeds taken from Fendler's specimens.

76. Callirrhoë* involucrata. (Malva involucrata, *Torr. & Gray, Fl.* 1. *p.* 226.)

* A genus first indicated by Nuttall under this name, which was subsequently changed to that of Nuttallia, but its diagnostic characters have not yet been given. Having been founded on exinvolucellate species, it was at first only compared with Sida. But as involucellate species with the same habit became known, it was proposed by Hooker (*Jour. Bot.* 1. *p.* 196) to refer the latter to Malva and the former to Sida. As the radicle, however, proved to be inferior in all of them, they were all placed in the genus Malva in the *Flora of North America* (except an obscure species, the characters of which were not entirely understood); and a new genus was dedicated to Mr. Nuttall. A closer study of the American species thrown into Malva and Sida reveals characters which induce me not only to restore this genus, but to propose some other genera. The character which, on the whole, decides the question in favor of separating *Callirrhoë* from Malva, namely, the transverse process in the carpel, has indeed been already observed by Dr. Torrey (*Fl. N. Amer.* 1. *p.* 682) in a single species which I now refer to it; but it equally exists in the others, though much less conspicuously in some of them. The leading character of the genus which I propose to call *Sidalcea*, namely, the double column separating into clusters of filaments, has also been noticed in the same work. The true *Napæa*, of Clayton, with diœcious flowers, a naked calyx, and an *inferior* radicle, is a totally distinct genus, which (in *Man. Bot. North. United States, p.* 69) I have already restored. There remain a set of ambiguous, perhaps all American, species, which have been referred to Sida when the involucel was inconspicuous, deciduous, or wanting, and to Malva when the involucel was manifest. From the latter, however, they differ by their capitate stigmas (a character which, though generally attributed to Malva, is found in no European species) and usually beaked fruit; and from Sida by the ascending ovule and inferior radicle. By separating these, under the name of *Malvastrum* (a name given by De Candolle to his division of Malva which comprises all the monospermous species, and which is no longer required now that the corresponding divisions are admitted genera), we leave both Malva and Sida much more natural and capable of exact definition. The genera in question would be characterized as follows.

On the Arkansas and the Cimarron. This handsome species I have had in cultivation (from seeds gathered by Col. Fremont) for several years in the Botanic Garden, Cam-

1. MALVA, *Tourn.*, *Linn.* (excl. sp.)

Involucellum triphyllum, persistens. Petala obcordato-biloba. Tubus stamineus simplex, filamentis singulatim exserentibus. Styli filiformes introrsum stigmatosi (hirtelli). Ovulum in loculis solitarium, peritropo-adscendens. Capsula depressa, polycocca; carpella rotundato-reniformia vel cochleata, omnino mutica, semini conformia, indehiscentia, ab axi centrali secedentia. Semen reniforme, loculum implens. Embryo arcuatus vel semicircularis: radicula infera. — Herbæ gerontogeæ; floribus purpureis, roseis, seu albis.

M. ROTUNDIFOLIA, *Linn.*, is extensively naturalized in North America.

M. BOREALIS, *Wallm.* (vide supra No. 75), has doubtless been brought from the Old World also.

M. malachroides, *Hook. & Arn. Bot. Beech. Suppl.*, from California, of which the fruit is unknown, is probably of a different genus.

M. Le Contei, *Buckley, in Sill. Jour.* 45. *p.* 176, = Pavonia Le Contei, *Torr. & Gray, ined.*, nearly allied to P. hastata, *Cav.*

2. CALLIRRHOË, *Nutt.*

Involucellum nullum, vel 1 – 3-phyllum persistens. Petala cuneiformia, truncata, apice sæpe croso-denticulata. Tubus stamineus, styli, ovula, etc., ut in Malva. Carpella plurima, in rostrum nudum breve crassum pl. m. incurvum seu rectiusculum desinentia, clausa, nunc tarde dehiscentia, intus processu ligulæformi dorsali infra rostrum cavum aucta! Semen subreniforme. Embryo arcuatus: radicula infera. — Herbæ Boreali-Americanæ, perennes, humiles; caulibus e radice napiformi crassa adscendentibus aut procumbentibus; floribus sæpius longe pedunculatis purpureo-rubris vel incarnatis.

Callirrhoë, *Nutt. in Jour. Acad. Philad.* 2. *p.* 181.

Nuttallia, *Dick; Bart. Fl. N. Amer.* 2. *t.* 62; *Hook. Exot. Fl. t.* 171, 172.

Malvæ spec., *Torr. & Gray, Fl.* 1. *p.* 225.

§ 1. MALVOIDEÆ. Involucellum ad basin calycis triphyllum: carpella suborbiculata, rostro et processu interno parvo inconspicuo.

1. C. TRIANGULATA: hirto-pubescens; radice tuberosa; caulibus adscendentibus; foliis triangulatis vel hastatis, radicalibus subcordatis, caulinis infimis deltoideis acuminatis grosse crenatis longe petiolatis, superioribus incisis, summis laciniato-3 – 5-fidis; bracteis minimis; floribus paniculatis; pedicellis subaggregatis flore (rubro-purpureo) brevioribus; involucelli phyllis linearibus apice spathulatis calycis segmenta ovata subæquantibus; carpellis lævibus rostello brevissimo apiculatis dorso uninerviis demum bivalvibus! — Malva triangulata, *Leavenworth in Sill. Jour.* 7. *p.* 62; *Gray, Man. Bot. N. U. S. p.* 70. M. Houghtonii, *Torr. & Gray, Fl.* 1. *p.* 225. Nuttallia triangulata, *Hook. Jour. Bot.* 1. *p.* 197. N. cordifolia, *Nutt. in Jour. Acad. Philad.* 7. *p.* 98. N. cordata, *Lindl. Bot. Reg. t.* 1938. — Dry prairies, from Wisconsin and Iowa to Georgia. — This species in its inflorescence and in the minuteness of the hollow beak, which is incurved as the fruit ripens so as to escape notice, makes the nearest approach to Malva; but the structure is really the same with that which is displayed on a larger scale in the following section. A carpel is figured in *Genera Amer. Bor.-Orientalis Illustrata*, 2. *t.* 218.

2. C. INVOLUCRATA: caulibus e radice napiformi longe procumbentibus pilis patentibus hirsutis; foliis pedato-5-partitis circumscriptione rotundatis, segmentis cuneatis insico-3 – 5-fidis, lobis dentibusque fol. infimo-

bridge, where it is perfectly hardy. The root, as in all the species, is large and napiform or conical.

rum obtusis superiorum lanceolatis acutis; stipulis ovatis majusculis; pedunculis axillaribus solitariis unifloris folio longioribus; involucelli phyllis lanceolatis calycis laciniis lanceolatis attenuato-acuminatis dimidio brevioribus; carpellis (circ. 20) rotundatis undique rugoso-reticulatis apice incurvo complanato brevissime rostellatis omnino clausis. — *Gray, Gen. Ill.* 2. *t.* 217, *ined.* Nuttallia involucrata, *Nutt. ex Torr. in Ann. Lyc. N. Y.* 2. *p.* 172. Malva involucrata, *Torr. & Gray, Fl.* 1. *p.* 226. — Plains, from the Platte to Texas and west to the Rocky Mountains. — I have for several years had this handsome species in cultivation in the Cambridge Botanic Garden, from seeds taken from specimens gathered by Col. Fremont. It forms a very large root, which stands the winter well in the open air. The showy flowers are cherry-red with a tinge of purple, deeper colored and one third smaller than in C. Papaver, and are produced from spring until late in autumn. On prolonged flowering stems the upper leaves are abortive, and a membranaceous bract, formed of the two united stipules, subtends the peduncle.

§ 2. Eucallirrhoës. Involucellum nullum, vel in M. Papavere 3–1-phyllum sæpeque a flore pl. m. remotum. Carpella rostro subuncinato viridi atque processu interno conspicuo donata. Pedunculi uniflori, apicem versus sæpe articulati.

* *Involucellum* 1–3-*phyllum, nunc in eadem stirpe nullum.*

3. C. Papaver: strigoso-hirsutula; caulibus e radice tuberosa adscendentibus gracillimis; foliis radicalibus subcordatis 3–5-fidis lobis oblongis paucidentatis, caulinis digitato-5–3-partitis, laciniis lineari-lanceolatis plerumque integerrimis; pedunculis axillaribus longissimis remotis; calycis laciniis parce hispidis ovato-lanceolatis attenuato-acuminatis; carpellis rugoso-reticulatis glabris rostro brevi incurvo apiculatis clausis. — Malva Papaver, *Cav. Diss.* 2. *p.* 64. *t.* 15. *f.* 3; *Torr. & Gray, Fl.* 1. *p.* 226 (excl. syn. sub C. triangul. citat.). M. nuttallioides, *Croom in Sill. Jour.* 26. *p.* 313. Nuttallia Papaver, *Graham in Bot. Mag. t.* 3287; *Hook. in Jour. Bot. l. c.* — Florida and Georgia to Texas, Arkansas, &c. Not rare in cultivation. Petals violet-red, an inch and a half long.

* * *Involucellum omnino nullum.*

4. C. digitata (Nutt.): glabriuscula, subglauca; caulibus adscendentibus gracillimis; foliis digitato-5–7-partitis, laciniis linearibus prælongis integerrimis rariusve 2–3-fidis, supremis simplicioribus; pedunculis axillaribus longissimis; calycis laciniis ovato-lanceolatis acuminatis; carpellis dorso pilosulis, cæt. ut in C. Papavere; floribus minoribus. — *Nutt. in Jour. Acad. Philad.* 2. *p.* 181. Nuttallia digitata, *Hook. Exot. Fl.* 3. *t.* 171, non *Bart.* Malva digitata, *Torr. & Gray, l. c.* — Prairies of Arkansas and Texas. Not well known. The fruit is smaller, and the beak of the carpels rather longer, than in the last, but smaller than in the following, from which it also differs in the rugose-pitted carpels, and in being less crested on the back, at the origin of the beak.

5. C. pedata: caule glabro erecto; foliis radicalibus imisque 5–7-fidis rotundatis, superioribus 3–5-partitis, segmentis laciniato-lobatis vel incisis, supremorum integriusculis seu integerrimis; pedunculis paniculato-racemosis vel corymbosis, calycis glabri laciniis acuminatissimis; carpellis lævibus glabris dorso ad originem rostri maximi cristato-3-crenatis e basi subdehiscentibus. — *Gray, Gen. Ill.* 2. *t.* 218. Nuttallia pedata, *Nutt. in Hook. Exot. Fl.* 3. *t.* 172. N. digitata, *Bart. Fl. N. Amer.* 2. *t.* 162, quoad tab. Malva pedata, *Torr. & Gray, l. c.* excl. β. — Prairies of Arkansas, near Fort Smith, &c., *Nuttall.* Texas, *Lindheimer.* Cultivated in the Cambridge Garden from Texan seeds, where it flowers the first year like an annual, but also

†77. C. INVOLUCRATA, var.; with the leaves less dissected. Low and moist places, Rabbit's Ear and McNees Creeks.

forms a thickened perennial root. The corolla is cherry-red (turning purplish in drying), handsome, 1½ to 2 inches in diameter. Petioles often hirsute. Head of fruit smaller than in the last. — Well characterized by the smooth carpels, with a very large and thick beak.

6. C. MACRORHIZA: caulibus strigulosis humilibus e radice napiformi; foliis radicalibus oblongo-cordatis, primariis crenatis integris, sequentibus hastato-lobatis varie incisis, caulinis pedato-3–5-partitis segmento intermedio majore 3–7-fido vel laciniato; pedunculis corymbosis foliis sæpe brevioribus; floribus parvulis albidis; calycis strigosi laciniis ovato-lanceolatis; carpellis rugosissimis. — Sida macrorhiza, *James! Mss. in Herb. Torr.* Malva pedata β? umbellata, *Torr. & Gray! Fl.* 1. *p.* 227; *Hook.! Lond. Jour. Bot.* 6. *p.* 76. — Plains of the Platte, *Dr. James*, *Fremont*, *Geyer.* — An entirely distinct species. The numerous stems, about a foot long, spring from a large edible root, which attains the diameter of from three to five inches. The peduncles are seldom two inches in length. The petals are white or nearly so, only half an inch long.

7. C. ALCÆOIDES: strigosa; caulibus erectis gracilibus; foliis "inferioribus triangulato-cordatis incisis" (*Michx.*), mediis hastato-5–7-partitis laciniatis, summis 3–5-sectis, segmentis linearibus; pedunculis corymbosis folia superantibus; floribus majusculis roseis vel albis; calycis hispidi laciniis triangulatis acutis; carpellis 10 hirsutulis dorso rugosissimis inferne dehiscentibus. — Sida alcæoides, *Michx.! Fl.* 2. *p.* 44; *Torr. & Gray! Fl.* 1. *p.* 234, & *Suppl. p.* 681. — Gravelly soil, Kentucky and Tennessee, *Michaux*, *Dr. Currey* (v. sp. in herb. Torr.). A foot high. Petals narrowly cuneiform, nearly an inch long. — Dr. Torrey (l. c.) noticed the conspicuous transverse dorsal process in the upper part of the cell of the carpel. It is, however, equally striking in the two preceding species, with which this is entirely congeneric. In these, also, the seed does not entirely fill the cell (below the process), and falling back somewhat the umbilical sinus is at length often directed obliquely upward more or less; but the structure and insertion are not as in Sida.

3. SIDALCEA, *Nov. Gen.*

Calyx involucello nullo nudus. Petala integra vel obcordata. Tubus stamineus apice duplex, nempe in phalanges 5 exteriores pluriantheriferas petalis oppositas, atque circiter 10 interiores vel filamenta subindefinita per paria coalita, solutus! Styli 5–9, introrsum stigmatosi. Ovulum in loculis solitarium, peritropo-adscendens. Capsula 5–9-cocca; carpellis membranaceis, reniformibus, muticis vel apiculatis, solubilibus, intus laceratione apertis. Semen adscendens, embryo arcuatus, et radicula infera ut in Malva. — Herbæ Am.-Bor. Occidentales; foliis rotundatis plerisque palmatifidis, radicalibus integriusculis; caule virgato; floribus rosco-purpureis albisve, racemosis.

Sidæ sp., *Lindl.*, *Nutt.*, *Torr. & Gray*, *Fl. l. c. no.* 14–17.

A genus well marked in habit and character; distinguished from Sida (to which the species have been referred on account of the naked calyx) by the ascending ovule and descending radicle as well as the unilateral stigmas, which occupy the whole inner face of the styles, as in Malva, &c.; from Malvastrum by the stigmas and the whole habit; from Callirrhoë by the beakless carpels; from Malva by the want of an involucre and the fewer carpels; and from all by the elimination of the stamens from the tube in the form of an outer and an inner series, and the combination of the filaments, at least of the outer series, into distinct and definite phalanges. This peculiarity is evident in all the species upon inspection, but is carried to the maxi-

78. SPHÆRALCEA MINIATA, *Spach, Hist. Nat. Veg. 3. p. 352? Gray, Gen. Ill. t. 230.* Malva miniata, *Cav. Ic. 3. p. 40. t. 278.* Fields and wet meadows, Santa Fé; June,

mum in S. diploscypha and the related species of the typical section. To which, if either, of the second section the Sida malvæflora of De Candolle (founded solely on a drawing by Moçino and Sesse) belongs, I cannot determine; perhaps to S. Neo-Mexicana. But, as Lindley has long since applied the name to the Oregon species, which again has been confounded with a third from California, it will be best to drop it altogether, or until the plant to which it really pertains can be identified.

§ 1. Phalanges exteriores staminum latæ membranaceæ, integræ, truncatæ, 5–8-antheriferæ, e medio columnæ exserentes, æstivatione convolutivæ; interiores terminales 10, angustæ, sæpius 2-antheriferæ; filamentis fere ad apicem coalitis.

1. S. DIPLOSCYPHA: annua, pilis patentissimis molliter hirsuta; caule paniculato-ramosa; foliis rotundatis longe petiolatis demum glabratis, radicalibus inciso-crenatis, caulinis 7-partitis, segmentis oblongis 2–3-fidis, floralibus sessilibus bracteisque 3–7-sectis segmentis lineari-filiformibus; floribus aggregatis brevissime pedicellatis; laciniis calycis 5-partiti lanceolatis sensim acuminatis; coccis liberis cochleato-reniformibus omnino muticis transversim-rugosis dorso sulcatis. — *Gray, Gen. Ill. 2. t. 222.* Sida diploscypha, *Torr. & Gray, Fl. 1. p. 234; Hook. & Arn. Bot. Beech. p. 236. t. 76.* — Var. β MINOR: omnibus partis minoribus; ramis paucifloris; petalis in sp. sicco purpuratis. California, *Douglas.* β. California, *Fremont, Hartweg.* — The petals in Douglas's specimens are pale, and as if barely tinged with purple. In those of Fremont and Hartweg they are dark and dull purple, a hue probably assumed or much deepened in drying; and the whole plant is smaller and more slender. It is from Fremont's specimens that I have described the fruit, which consists of from 7 to 9 pretty large carpels; these are thin and membranaceous, and open by a rent at the inner angle as they separate. — The figure in *Bot. Beech.* does not show the division of the inner stamineal column at the summit into 10 narrow phalanges, of which five are alternate with the broad exterior phalanges, and five alternate with these.

2. S. CALIFORNICA: perennis? undique cinereo-tomentosa; caule simplici stricto (pedali); foliis cordato-orbiculatis velutinis crenato-dentatis subincisis, inferioribus vix lobatis, summis 5–7-fidis brevi-petiolatis; racemo simplici; calyce pedicello brevissimo bracteaque duplo longioribus, laciniis ovato-lanceolatis. — Sida Californica, *Nutt.! in Torr. & Gray, Fl. 1. p. 233.* — Santa Barbara, California, *Nuttall.* — Most resembles S. humilis. The single specimen I have seen is barely in flower. The fruit is therefore unknown; but the ovule is ascending. The stamineal column is nearly as in the preceding.

3. S. DELPHINIFOLIA: annua; caule stricto simplici superne hirsutissimo; foliis (radicalibus non visis) caulinis 7-partitis sectisve, segmentis linearibus angustis (1½–1 unc. longis lineam latis) simplicibus; racemoso denso multifloro basi foliato; calyce hirsutissimo 5-partito pedicello duplo longiore, laciniis lineari-lanceolatis; coccis reticulatis glabriusculis rostello molli erecto hispido apiculatis. — Sida delphinifolia, *Nutt.! in Torr. & Gray, Fl. 1. p. 235.* — Santa Barbara, California, *Nuttall.* California, *Hartweg.* — I have drawn the character from a Hartwegian specimen (the specimen of Nuttall in Dr. Torrey's herbarium being imperfect), which, having the root, shows that the plant is an annual; but the radical leaves are wanting. Stem 14 inches high, terminated by a short raceme of crowded showy flowers. Calyx half an inch, the purple petals fully an inch, in length. Stamineal column as in No. 1; the broad exterior phalanges strongly convolute in æstivation and inclosing the inner. Carpels 7 to 9, smaller than in No. 1, finely reticulated, tipped with a short, perhaps not persistent, hairy beak: when removed they leave a pretty large ventral

in flower, August, with mature fruit. — This plant was also gathered by Lieut. Abert. The native country of Malva miniata, *Cav.* was not recorded. But that the plant is a

portion attached to the short axis, which is conspicuonsly 7 – 9-winged. The fruit is figured in *Gen. Ill.* 2. *t.* 224.

§ 2. Phalanges exteriores ex apice columnæ exserentes, sæpe bifidæ, in filamenta 4 – 6 usque ad medium vel profundiora fissæ; interiores e filamentis subindefinitis inferne binatim connatis.

* *Annuæ, paucifloræ.*

4. S. HARTWEGI: caule tenello subsimplici apice 2 – 4-floro inferne foliisque parvis 5-partitis glabratis, segmentis superiorum linearibus integris, imorum spathulatis apice interdum bilobis; bracteis minimis; calycis brevi-pedicellati tomentulosi laciniis triangulari-lanceolatis acuminatis; corolla lilacina. — California, *Hartweg* (No. 1669). — Plant 7 – 9 inches high. Segments of the leaves about half an inch long. Petals two thirds of an inch in length. Fruit unknown. — From the aspect and the disposition of the flowers, this plant would seem to be closely allied to S. diploscypha; but in the stamineal column it accords with the ensuing species.

* * *Perennes: flores virgato-racemosæ.*

5. S. HUMILIS: undique hispido-hirsuta; caulibus e radice tuberosa adscendentibus simplicibus (6 – 12 unc. altis); foliis radicalibus rotundis sinu apertis aut subtruncatis inciso-crenatis indivisis sublobatisve, caulinis (2 – 4) 5 – 7-partitis, segmentis apice trilobatis obtusis; racemo brevi (9 – 15-floro) basi foliato; calycibus pedicello longioribus, laciniis lanceolatis acuminatis; corolla roseo-purpurea. — Sida malvæflora, *Hook. & Arn. Bot. Beech. p.* 326; an *DC.*? — Var. β. humilior, foliis omnibus indivisis seu vix lobatis rotundato-reniformibus basi pl. m. truncatis. — California, *Douglas*, *Fremont*, *Hartweg*. β. From a Russian collection made in the Bay of San Francisco. — This species is not more than a quarter of the size of S. Oregana, with the leaves only an inch or little more in diameter, while the flowers are much larger, the petals being fully an inch in length. Fruit unknown.

6. S. OREGANA: caule virgato (1½ – 3-ped.) superne cinereo-puberulo sæpe paniculato; foliis (hirsutis v. glabratis) radicalibus reniformi-orbiculatis 7 – 9-lobatis, primariis sinu apertissimis vel truncatis, caulinis 3 – 7-partitis, segmentis 2 – 3-fidis lobis apice 3-dentatis vel summorum integerrimis; racemo prælongo tomentello; calycibus tomentosis pedicellum superantibus seu æquantibus, laciniis triangulari-ovatis acuminatis demum attenuatis; corolla rosea vel "rubra"; coccis fere lævibus angulo interno apiculatis. — Sida malvæflora, *Lindl. Bot. Reg. t.* 1036; *Hook. Fl. Bor.-Am.* 1. *p.* 108; *Torr. & Gray*, *Fl. l. c.*, vix *DC.* S. Oregana, *Nutt.! in Torr. & Gray*, *l. c.* (var. minor, glabrior). Nuttallia malvæflora, *Fisch. & Mey. Ind. Sem. Hort. Petrop.* 1837. Southern Oregon, *Douglas*, *Nuttall*, *Geyer*, *Mr. Spalding*. — Radical and lower leaves large, 3 or 4 inches in diameter. Petals half an inch in length.

7. S. NEO-MEXICANA: vide p. 23, No. 79.

8. S. CANDIDA: vide p. 24, No. 80.

4. NAPÆA, *Clayt.*

Flores dioici. Involucellum nullum. Calyx teres 5-dentatus. Tubus stamineus simplicissimus, in stamina 15 – 20 uniserialia solutus. Cætera Malvæ. — Herba procera; foliis palmato-multifidis laciniatis, radicalibus maximis; floribus parvis, umbellato-fasciculatis, albis.

N. DIOICA, *Linn. Spec.* 2. *p.* 686, & *Amœn.* 3. *p.* 18; *Gray*, *Man. Bot. N. U. S. p.* 69, & *Gen. Ill.* 2. *t.* 225. Sida dioica, *Cav. Diss.* 5. *p.* 278. *t.* 132. *f.* 1; *DC. Prodr.* 1. *p.* 465; *Torr. & Gray*, *Fl.* 1. *p.* 234

Sphæralcea would appear from the character of "capsulæ dispermæ," (although in fact only one seed commonly ripens,) and I suspect that this is the very species, although

& *p.* 681. — A well-marked genus, as founded by Clayton: but Linnæus subsequently added a second species (N. hermaphrodita & N. lævis; the Althæa ricinifolia, *Herm. Lugd. p.* 22. *t.* 23. Sida Napæa, *Cav. l. c.*), which is a true Sida in all its technical characters. The latter, Hermann states to have been raised from seeds brought from Virginia; but as it has long been widely diffused in cultivation, while it has nowhere been found wild in the United States, I suspect that it is not of North American origin.

5. MALVASTRUM, *Nov. Gen.*

Calyx nudus, seu bracteolis 1–3 setaceis caducis, raro involucello triphyllo persistente, stipatus. Stigmata terminalia capitellata. Tubus stamineus simplex, ovulum peritropo-adscendens, embryo semicircularis, atque radicula infera Malvæ. Carpella mutica vel rostrata. — Herbæ Americanæ; floribus coccineis, aurantiacis, aureisve, axillaribus, raro racemosis. Malvæ et Sidæ sp., *Auct.*

The propriety will scarcely be doubted of associating in a separate genus such closely related species as those of the first section, which have been arbitrarily and variably referred, sometimes to Malva and sometimes to Sida, but which are capable of being clearly and precisely distinguished from either. If the yellow-flowered species with a somewhat different habit and usually a manifest persistent involucre, which form the second section (the Chrysanthæ, *DC.*, &c.), are correctly referred to this genus, it will comprise a large number of species from tropical and South America, which need an elaborate revision. I enumerate below merely the North American species which are known to me.

§ 1. Flores miniati. Involucellum nullum, vel parvum, e bracteolis 1–2, rarius 3, setaceis plerumque caducis. Carpella mutica. — Herbæ stellato-incanæ, perennes.

1. M. COCCINEUM: vide p. 24. — Sida coccinea; and β. S. dissecta, *Nutt.*, etc.

2. M. GROSSULARIÆFOLIUM. — Sida grossulariæfolia, *Hook. & Arn. Bot. Beech. p.* 326. Malva Creeana, *Graham, in Bot. Mag. t.* 3698? (Of this I find no specimen in herb. Graham.)

3. M. MUNROANUM. — Malva Munroana, *Dougl. in Bot. Reg. t.* 1306. M. fasciculata, *Nutt.! in Torr. & Gray, Fl.* 1. *p.* 225.

4. M. FREMONTII (*Torr. ined.*): lana alba dense implexa undique tomentissimum; foliis rotundatis basi truncatis crenatis subtrilobis breviter petiolatis; floribus in axillis glomeratis subsessilibus, bracteolis involucelli 3 setaceis calyce lanatissimo brevioribus. — Interior of California, *Fremont.* The plant is apparently low and spreading, and extremely woolly, but the wool seems to be more or less deciduous from the adult leaves, which are nearly two inches broad. The unopened flower-buds resemble pellets of wool. The expanded corolla is an inch in diameter. Fruit unknown.

Along the Andes are numerous species, among which is Malva humilis, *Gillies! in Hook. Bot. Misc.* 3. *p.* 150; but the M. sulphurea, *Gillies! l. c.* is an involucellate Sida, of the same group as S. hederacea.

§ 2. Flores flavi. Involucellum sæpius triphyllum persistens. Carpella 1–3-cuspidata vel mutica.

5. M. WRIGHTII (sp. nov.): pube brevissima stellata undique lepidoto-cinereum; caulibus adscendentibus e radice perenni parce ramosis; foliis oblongo-ovatis dentatis obtusis basi rotundatis truncatisve petiolo duplo longioribus; pedunculis axillaribus solitariis unifloris brevissimis; bracteolis involucelli 3 ovatis vel subcordatis persistentibus tubo calycis adnatis lacinias ejusdem triangulari-ovatas acuminatas subæquantibus; carpellis 15–20 plano-compressis apice hirtis extus bilamellato-gibbosis, acie ventrali in cuspidem subulatam produc-

the flowers are not so large as is represented in the figure of Cavanilles. Our plant is herbaceous. — The Sphæralcea stellata, *Torr. & Gray, Fl. l. c.* is probably only a smaller-

ta. — Texas, *Mr. Charles Wright*, *Lindheimer!* — Stems 1 to 2 feet high. Leaves thickish, about 1½ inch long; the lower ones rounder. Peduncle one third of an inch in length, rather shorter than the calyx. Petals golden-yellow, oblique, three fourths of an inch long.

✓ 6. M. CARPINIFOLIUM. — Sida carpinifolia, *Linn. f. Suppl. p.* 307; *Cav. Diss.* 1. *t.* 134. *f.* 1; *DC. Prodr.* 1. *p.* 461; *St. Hil. Fl. Bras.* 1. *p.* 184; *Webb. & Berth. Canar.* 2. *p.* 37. S. planicaulis, *Cav. Diss. t.* 3. *f.* 11. S. spirlæfolia, *Willd. Enum. Suppl. fide Walp.* S. bracteolata, *DC.* and S. carpinoides, *DC. l. c.* Malva tricuspidata, *Ait. Kew. ed.* 2. 4. *p.* 210. M. subhastata, *Cav. Diss.* 2. *p.* 72. *t.* 21. *f.* 3; *St. Hil. l. c. p.* 214. M. Americana, *Cav. l. c. t.* 22. *f.* 2. M. Domingensis, *Spreng. in DC. l. c.?* — Key West, *Blodgett!* Texas, *Lindheimer! Wright!* Mexico, *Coulter! Gregg!* &c. — Of the greater part of these synonymes I entertain no doubt. The native Texan specimens, and those in cultivation raised from Texan seeds, which, having comparatively simply toothed leaves, the lower broadest at the base or deltoid-ovate, represent the Malva tricuspidata and the Sida carpinoides of De Candolle, agree far too closely with S. carpinifolia from Madeira (which is probably of American origin) to allow of a specific distinction. The calyx in all is tribracteolate, or only 1–2-bracteolate in some of the later flowers. The fruit appears to be absolutely alike in both. The depressed capsule consists of about 10 (8–11) conduplicate-reniform carpels with a very deep ventral sinus, armed with two short cusps or points on the back, and with a much longer and setaceous apical one ("carpellis 3-cuspidatis," and "carpellis dorso breviter bicornutis et basi interna 1-aristatis"), which in dehiscence is bipartible (then "carpellis biaristatis"). The seed is deeply reniform and conformed to the cell, and the embryo semiannular, with the radicle inferior and centripetal.

(M. SPICATUM, = Malva spicata, *Linn.*, which was gathered by Dr. Gregg at Monterey, Mexico, has somewhat similar, but pointless, carpels.)

✓ 7. M. ANGUSTUM: annuum, appresse pilosum; caule gracili; foliis lanceolatis vel lineari-oblongis petiolatis rariter serratis; stipulis setaceis; pedunculis axillaribus plerumque solitariis circ. longitudine petiolorum; bracteolis involucelli 2–3 setaceis calyce brevioribus; segmentis calycis latissime ovatis subcordatis acuminatis post anthesin ampliatis; carpellis 5 obtusis omnino muticis puberulis lævibus membranaceis mox bivalvibus. — Sida hispida, *Pursh*, *Fl.* 2. *p.* 452? *Hook.! Jour. Bot.* 1. *p.* 198. Malva perpusilla, *Nutt.! Mss. in Herb. Torr.* (spec. depaup.) — This is probably Pursh's plant; but I have not seen it from Georgia. Drummond gathered it at St. Louis, whence I have also received it from Dr. Engelmann; and Nuttall found depauperate specimens on the plains of Red River. The carpels and seed are reniform, and the radicle centripetal-inferior.

6. SIDA, *Linn.* (excl. sp.)

Calyx sæpius angulatus, nudus, rarove bracteolis 1–2 deciduis involucellatus. Tubus stamineus simplex. Stigmata terminalia capitellata. Ovulum in loculis solitarium, resupinato-suspensum! Capsula 5–15-cocca; carpella rectiuscula indehiscentia vel sæpius apice bivalvia, ab axi centrali tarde secedentia. Semen subtrigonum, umbilico sursum spectante. Embryo conduplicatus, curvatura infera, radicula (ventrali) cotyledonibusque superis! — Herbæ aut suffrutices (plerisque tropicis v. subtropicis); foliis sæpius indivisis.

Sida, *Kunth in H. B. K. Nov. Gen.* (excl. sp.); *Adr. Juss. in St. Hil. Fl. Bras.*

Malvinda, *Medik. Malv.* 23.

flowered variety of S. angustifolia. Sphæralcea rivularis, *Torr.! ined.* (Malva rivularis, *Dougl.*) has been ascertained by Dr. Torrey to be the same as S. acerifolia, *Nutt.* Malva vitifolia, *Cav.* is probably another species of the genus nearly allied to the last. S. incana, *Torr. ined.* gathered by Lieut. Abert in New Mexico, and also by Wislizenus, is perhaps too nearly related to our No. 78, but more canescent with a closer and finer pubescence: S. Emoryi, *Torr. ined.* is still another allied species, with hastate or triangular leaves and a rougher pulverulaceous tomentum. S. pedata, *Torr. ined.*, gathered in Fremont's third expedition, has 3–5-sected leaves; the divisions all cuneiform, 3-lobed and incised.

✓ 79. Sidalcea Neo-Mexicana (sp. nov.): caule virgato gracili superne glabro inferne cum petiolis foliisque sparsim hirtellis; foliis radicalibus orbiculatis sinu apertis leviter 5–9-lobatis vel insico-crenatis, primariis basi subtruncatis, caulinis infimis profunde 7–9-fidis superioribus 5–3-partitis, segmentis 3-lobatis apice dentatis, supremorum linearibus integerrimis; racemo multifloro; pedicellis strictis calyce hirsuto duplo longioribus; corolla lilacina; coccis lævissimis angulo interno mucronato-apiculatis. — Vide p. 20. Moist meadows, Santa Fé; June, July. (Also, a slender form with the lower leaves more divided, at San Juan de la Vequeria, Tamaulipas, *Dr. Gregg.*) — Plant 12 to 18 inches high, at first simple, with a long, virgate raceme, soon producing axillary flowering

§ 1. Pseudo-Malvastrum. Involucellum e bracteolis 1–3 setaceis parvis, deciduum. Carpella omnino mutica. Stellato-incanæ, floribus flavis croceisve.

S. hederacea, *Torr.! ined.* = Malva hederacea, *Dougl. in Hook. Fl. Bor.-Am.* 1. *p.* 107. M. Californica, *Presl! Rel. Hænk.* 2. *p.* 121. M. plicata, *Nutt.! in Torr. & Gray, l. c.* M. obliqua, *Nutt.! Mss.* Sida obliqua, *Torr. & Gray! l. c.* — Southern Oregon, *Douglas, Nuttall.* California, *Hænke, Coulter, Fremont.*

S. sulphurea, = Malva sulphurea, *Gillies! in Hook. Bot. Misc.* 3. *p.* 149, from Mendoza, is a nearly related species; and some others from the same region usually referred to Malva probably belong here.

§ 2. Malvinda, *Medik.* Calyx omnino nudus, 5-angulatus, 5-fidus. Carpella pl. m. rostrata, 2–3-cuspidata vel aristata. Flores plerumque flavi.

S. spinosa, *Linn.*, et cæteris div. * & * * *Torr. & Gray, Fl. l. c.*, etc.

§ 3. Pseudo-Napæa. Calyx omnino nudus, teres, 5-dentatus. Flores umbellati-corymbosi, albi. Folia palmatifida.

S. Napæa, *Cav.* = Napæa hermaphrodita, *Linn.* (Vide p. 21.)

S. Hulseana, *Torr. & Gray, l. c.* (Abutilon Hulseanum, *Torr. ined.*) is probably Abutilon confertiflorum, *A. Rich.*

S. crispa, *Linn.* (which grows on Key West and in Texas) has 3–4-ovulate carpels, and is therefore an Abutilon, notwithstanding its close resemblance to Bastardia, to which Adr. Jussieu referred it.

A revision of the North American species of Sida, as thus restricted (of which there are several new or undetermined species from Texas, &c.), will be attempted on another occasion.

branches. Bracts mostly 3-cleft and as long as the pedicels. Calyx-lobes triangular-acuminate, growing longer and more slender with age, as in the S. Oregana. Petals nearly half an inch in length. It is a smaller and more slender plant than the S. Oregana. A full account of this genus is given in the subjoined note (p. 18 et seq.). The species have been for the most part referred to Sida, with which they have little in common excepting the naked calyx.

✓ 80. S. CANDIDA (sp. nov.): caule folioso inferne petiolisque parce hirtellis; foliis inferioribus et radicalibus orbiculatis sinu clausis 7-lobatis lævibus ciliolatis, lobis cuneato-rotundatis grosse 3–5-crenatis incisisve, supremis 7- (floralibus 3–5-) partitis, segmentis lanceolatis integris; stipulis ovalibus: racemo brevi compacto glandulosi-tomentoso; pedicellis brevissimis; calycis tomentosi laciniis ovatis obtusiusculis; corolla alba; coccis lævibus glabris angulo interno apiculo pubescente mucronatis. — *Gray, Gen. Ill. t.* 224. — Along Santa Fé Creek; June, July. Plant 18 inches high; the stems simple from a perennial creeping rhizoma, glabrous except the scattered bristly hairs below: the smooth leaves almost exactly orbicular in circumscription, 2 to 2½ inches in diameter. Raceme spicate, only 3 or 4 inches long, densely flowered, not elongating in fruit, leafy at the base, glandular-downy, as well as the calyx; the upper bracts linear or lanceolate and little longer than the pedicels: the latter are spreading, shorter than the calyx, 2 to 3 lines long. Petals apparently pure white, obovate, over half an inch long. Staminal column slender, hairy (as in the other species), the phalanges less distinct than in the foregoing. Anthers blue. Carpels 9 or 10, cochleate-reniform, minutely apiculate at the inner angle. — A remarkable variety of this fine species, having larger cauline leaves with a very open sinus, and subsessile flowers, was gathered by Col. Fremont in his third expedition, probably in the Rocky Mountains.

✓ 81, 82. MALVASTRUM COCCINEUM: humilis, incanum; caulibus e basi sublignosa ramosis diffusis: foliis trisectis tripartitisve, segmentis lateralibus sæpius bipartitis intermedio trifido, lobis oblongis linearibusve integris seu paucidentatis; floribus inferioribus solitariis rariusve geminis in axillis foliorum, superioribus in racemum strictum digestis; bracteis subulatis deciduis; bracteolis involucelli 1–2 setaceis fugacibus; coccis 9–12 clausis dorso subtuberculatis cano-tomentosis. — *Gray, Gen. Ill. t.* 219. Cristaria coccinea, *Pursh! Fl. 2. p.* 453. Malva coccinea, *Nutt.! Gen. 2. p.* 81; *Bot. Mag. t.* 1643. Sida coccinea, *DC. Prodr.* 1. *p.* 465; *Hook. Fl. Bor.-Am.* 1. *p.* 108; *Torr. & Gray! Fl.* 1. *p.* 235. — Var. *β.* DISSECTUM: nanum; foliis 3–5-partitis, segmentis 3–5-fidis lobisque anguste linearibus. Sida dissecta, *Nutt.! in Torr. & Gray, l. c.; Hook. & Arn.! Bot. Beech. Suppl. p.* 327. — Plains, &c., Santa Fé, and east to Rock Creek and Poñi Creek of the Canadian: June to September. In flower and fine fruit. Some varying

forms as to foliage are distributed under these numbers; under one of them there are a few specimens of the var. *dissecta*, or of forms that evidently connect the Sida dissecta of Nuttall with the S. coccinea. I have for several years cultivated this species, from seeds brought from the Upper Missouri by Mr. Sprague, and had ascertained that its radicle is inferior, as in Malva. — An account of the genus, of which this is one of the typical species, is given in the subjoined revision of the genera allied to Malva.

LINACEÆ.

83. Linum perenne, *Linn.; Hook. Fl. Bor.-Am.* 1. *p.* 106. Santa Fé, in flower; May. Mora River, &c., in fruit; August.

† 84. L. Berlandieri, *Hook. Bot. Mag. t.* 3480 (sphalm. L. Berendieri); *Engelm. & Gray, Pl. Lindh. no.* 22. (L. annuum, *Nees in Neuwied. Trav.*) On the Cimarron River.

85. L. Berlandieri, var. with smaller flowers and more glaucous, rigid leaves. Specimens from dry and gravelly hills around Santa Fé, May, are entirely glabrous. Others, from the Cimarron River, &c., August, have a puberulent stem.

† 86. L. rigidum, *Pursh, Fl.* 1. *p.* 210. Prairies, Upper Arkansas.

GERANIACEÆ.

87. Erodium cicutarium, *L'Her.; DC. Prodr.* 1. *p.* 646. (E. cheilanthifolium, *Dougl. Mss.*) Santa Fé Creek; April to November.

88. Geranium Richardsonii, *Fisch. & Mey. Ind. Sem. Petrop.* 1837. (G. albiflorum, *Hook. Fl. Bor.-Am.* 1. *p.* 116. *t.* 40, *& Bot. Mag. t.* 3124; *Torr. & Gray, Fl.* 1. *p.* 207, non *Ledeb.* G. Hookerianum, *Walpers, Repert.*) Shady and moist places along Santa Fé Creek; June, July.

89. G. cæspitosum (*James*): perenne, humile; caulibus diffusis ramosis cum petiolis pedicellisque retrorsum pubescentibus; foliis parvulis rotundatis profunde 5-lobis (v. radicalibus 7-fidis) pubescentibus pallidis, segmentis cuneiformibus divaricatis inciso-lobatis; pedunculo prælongo pedicellis binis fructiferis declinatis quadruplo longiore; petalis obovatis integris purpureis intus secus nervos parce villoso-barbatis sepalis cano-puberulis aristatis paulo longioribus: filamentis patentibus basi pilosis calycem et stylos nudos tertia parte connatis superantibus; carpellis pilosiusculis; rostro puberulo. (G. cæspitosum, *James, in Long's Exped.* 2. *p.* 3, ex char. et loco natali.) — Santa Fé Creek, near irrigating ditches, at the foot of mountains; May to July; and six miles east of the Mora River; August. — A low species, producing numerous assurgent or decumbent stems (3 – 10 inches long), from a thickened caudex; the leaves an inch, or at most two inches,

in diameter; the lower rounded-reniform in outline, the upper with the three principal segments divaricate. Corolla when fully expanded an inch or less in diameter, deep purple. — Well distinguished from its allies, as Dr. Engelmann remarks, by its long filaments, which are recurved-spreading in anthesis, and by the much elongated peduncles with comparatively short pedicels. Dr. Engelmann had indicated it as a new species; but I am so confident that it is the species noticed and imperfectly characterized by Dr. James, that I venture to revive his name, which, unless thus identified, must ever remain appended to the genus as a doubtful species, since no specimens of it exist in the collection made by him in Long's Expedition.

✓ †90. G. Fremontii (*Torr.! in Pl. Frem. cum ic. ined.*): perenne; caulibus diffusis petiolisque retrorsum pubescentibus: foliis pubescentibus, superioribus profunde 3–5-fidis basi truncatis, infimisve sinu lato cordatis, radicalibus 7-fidis, segmentis 3-lobatis vel inciso-tridentatis mucronato-acutatis; pedicellis binis cum sepalis breviter aristatis glanduloso-pubescentibus pedunculum abbreviatum 2–3-plo superantibus, fructiferis subdeclinatis; petalis obovatis emarginatis (pallide purpureis) basi villosis ad venas parce villoso-barbatis: filamentis piloso-ciliatis stylos nudos ima parte solum connatos æquantibus; carpellis pilosis; rostro glanduloso-pubescente; seminibus tenuiter reticulatis. — Bottom lands of the Mora River, among shrubs; August. (Also in the Raton Mountains, *Lieut. Abert*, and probably farther north and west by *Col. Fremont.*) — Stems weak, at first erect, two feet high. Radical leaves 2 or 3 inches in diameter. Peduncles ½ to 2 inches, the pedicels 1 to 3 inches, in length. Flowers larger than in the preceding, from which it is readily distinguished. Dr. Engelmann remarks, that it is "rather too near G. pentagynum [which I suspect is G. incisum, *Nutt.*]; but may be distinguished by the slender stem, the broadly cordate or truncate base of the leaves, the shorter points of the sepals, &c. G. pentagynum is remarkably stiff and erect; the leaves deeply cordate, thick, silky with a fine appressed pubescence, and with prominent veins." Fendler's specimen, like one of Lieut. Abert's, is rather less pubescent and more diffuse than the original one of Fremont, the petals of which would appear to have been pale purple, if not white. In the others they are light purple, with deeper-colored veins.

* Dr. Engelmann, who has attentively studied our Gerania, proposes the following disposition of the North American species of this group, viz.: —

Perennes; pedunculi biflori; valvulæ capsulæ læves, plus minus pilosæ; semina reticulata seu rugosa.

* *Pedicelli deflorati erecti seu suberecti.*

1. G. Richardsonii, *Fisch. & Mey.* (G. albiflorum, *Hook., Torr. & Gray*; non *Ledeb.*): caule erecto cum petiolis glabriusculo; pedicellis tenuiter glanduloso-pubescentibus; filamentis basi pilosis calycem et stylos pilosos tertia parte connatos æquantibus; valvis capsulæ parce pilosiusculis; rostro glanduloso-pubescente;

OXALIDACEÆ.

91. Oxalis Vespertilionis, *Torr. & Gray, Fl.* 1. *p.* 679. Low places, Santa Fé; July, Aug. — Perhaps only a smaller-flowered variety of O. violacea, with more deeply lobed leaflets.

†92. O. stricta, *Linn.* Upper Arkansas; September.

BALSAMINACEÆ.

†93. Impatiens pallida, *Nutt. Gen.* 1. *p.* 146. Western Missouri to Council Grove; August.

petalis albis. — Distinct from the next by the greater smoothness, the hairy and much less connate styles, the pilose (not short-ciliate) filaments, and the more delicately reticulated seeds.

2. G. maculatum, *Linn.:* caule erecto cum petiolis retrorso-piloso; pedicellis glanduloso-pubescentibus; filamentis basi breviter ciliatis calyce stylisque nudis ultra medium connatis subbrevioribus; valvis capsulæ longe pilosis; rostro glanduloso-pubescente.

3. G. pentagynum, *Engelm. in Wisl. Rep.:* caule erecto cum petiolis retrorso-pubescente; pedicellis glanduloso-pubescentibus; filamentis basi pilosis calycem et stylos nudos ima parte solum connatos æquantibus; valvis capsulæ pilosiusculis; rostro glanduloso-pubescente. — Eastern Mountains of New Mexico, on Wolf Creek. — Nearer G. maculatum than any of the others: distinguished by the characters above enumerated; also by the finer, more closely adpressed pubescence, the smaller leaves with narrower segments and much more prominent veins; inner sepals with colored margins, emarginate or somewhat bilobed: seed not seen.

4. G. Fremontii, *Torr.* — Vide supra, p. 26.

5. G. Mexicanum, *Kunth.*

* * *Pedicelli deflorati declinati seu refracti.*

\+ *Flores violacei.*

6. G. cæspitosum, *James.* — Vide supra, p. 25.

7. G. gracile (sp. nov.): caule erecto divaricato-ramoso cum petiolis et pedicellis retrorso-piloso; filamentis basi piloso-ciliatis calyce et stylis pilosis ima parte solum connatis brevioribus; valvis capsulæ pilosiusculis; rostro pubescente. — Pine woods, on the mountains of Cosiquiriachi, State of Chihuahua; collected in October, by *Dr. Wislizenus.* — Resembling the last; but erect, more hirsute-pubescent; the flowers, fruit, and seed smaller; stamens shorter; styles hairy, more deeply divided; and the peduncles much shorter, mostly of the length of the pedicels. — Near G. Mexicanum, *Kunth?*

\+ \+ *Flores albidi.*

8. G. Hernandezii, *DC.:* caule divaricato-ramoso cum petiolis patentim piloso; pedicellis glanduloso-pilosis; filamentis basi breviter ciliatis calycem et stylos pilosos ad medium connatos æquantibus; valvis capsulæ parce pilosiusculis; rostro glanduloso-piloso. — Pine woods, on the mountains of Llanos, State of Chihuahua; collected in October, by *Dr. Wislizenus.* — Leaves 1¼ to 2 inches in diameter, the upper truncate at the base; peduncles as long as, or shorter than, the pedicels; flowers white, about 8 lines in diameter.

ZANTHOXYLACEÆ.

✓ 94, 95. PTELEA ANGUSTIFOLIA, *Benth.! Pl. Hartw. no.* 42. Steep and rocky banks of the Rio del Norte: No. 95, in flower, May; No. 94, in fruit. "Shrubs from 7 to 10 feet high: leaves of an agreeable odor." — The foliage becomes smooth and shining above with age. The fruit (which is wanting in the Hartwegian specimens) is much smaller and more emarginate than in P. trifoliata; and, like that species, it is frequently tricarpellary.

ANACARDIACEÆ.

†96. RHUS COPALLINA, *Linn.* Bottoms, along the Kansas River.

97. R. GLABRA, *Linn.* var.? R. lævicaulis, *Torr. in Bot. Ex. Exped. ined.* Steep mountain-sides, valley of Santa Fé Creek; July. — This clearly belongs to the Oregon species which Dr. Torrey distinguishes from R. glabra, on account of its short calyx, "scarcely half the length of the petals, linear-oblong anthers," &c. But a specimen from New York has nearly as short a calyx, while in others it is as long as the corolla. Being sub-polygamous plants, I suspect that the difference may be attributed to sex.

98. R. TOXICODENDRON, *Linn.; Torr. & Gray, Fl.* 1. *p.* 218. Valley of Santa Fé Creek, in the mountains; June.

✓ 99. R. (LOBADIUM) TRILOBATA, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 219. Rocky precipices, overhanging the Rio del Norte, in flower and fruit; May. Also on the Mora River, in ripe fruit; August. Shrub 3 to 8 feet high: possesses a peculiarly disagreeable odor. — Some (fruiting) specimens are nearly glabrous, as described by Nuttall: others are softly cinereous-tomentose. The ripe fruit is scarlet, and sparsely hirsute.

ZYGOPHYLLACEÆ.

✓ 100. KALLSTRŒMIA MAXIMA, *Torr. & Gray, Fl.* 1. *p.* 213. (Tribulus maximus, *Linn.*) Plains and waste places, Rio del Norte and around Santa Fé; May to Aug. — The inappropriate specific name was derived from the Tribulus terrestris major, *flore maximo* of Sloane; but the flower is far smaller than in T. cistoides, *L.* The latter (which grows on Key West, &c.) is a genuine Tribulus.

ACERACEÆ.

✓ 101. ACER TRIPARTITUM, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 247. Shady places, near the creek, in the mountains east of Santa Fé; May, in flower; June, in fruit. A shrub 15 feet high, of slender growth. — A beautiful species, allied to A. glabrum,

*Torr.** The shoots of the season are purple, but become ash-gray the following year. The small leaves are green on both sides; the first which appear from the bud are 3-parted, but all the succeeding are quite divided into three subsessile leaflets.

102. Negundo aceroides, *Mœnch*, var.? ramulis petiolisque cinereo-glaucis; foliis omnibus trifoliolatis. — Mountains east of Santa Fé, on the creek, in low situations; April, May. Large trees; the lower part of the trunk generally very knotty, which seems to arise from the many wounds the tree receives early in spring, in order to draw the sap from it, which is collected in cavities cut into the trunk a little beneath the wounded places. — There are fine male and female specimens, and also the fruit.

CELASTRACEÆ.

† 103. Staphylea trifolia, *Linn.* Twenty-five miles east of Council Grove.

† 104. Celastrus scandens, *Linn.* On the Upper Arkansas.

105. Pachystima Myrsinites, *Raf. in Amer. Month. Mag.* 1818. (Ilex? Myrsinites, *Pursh.* Myginda myrtifolia, *Nutt. Gen.* 1. *p.* 109. Orcophila, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 258, not of *Don.*) Var. major (Myginda myrtifolia *β.* major, *Hook. Fl. Bor.-Am.* 1. *p.* 120. *t.* 41, the right-hand figure). Valley of Santa Fé Creek, in the mountains, at the foot of precipices; May, June, in flower only. A foot high. Leaves thrice the size of those of the ordinary Oregon plant (which I have not seen so strongly serrate as in Hooker's figure), the larger even an inch and a half long, and more inclined to be acute; the flowers also rather larger.

RHAMNACEÆ.

106. Ceanothus Fendleri (sp. nov.): intricato-ramosissimus; ramis ramulisque teretibus gracilibus sæpe spinescentibus cinereo-puberulis demum glabratis lævibus; foliis parvulis ($\frac{1}{3}$–$\frac{1}{2}$ unc. longis) ovalibus seu ellipticis obtusis integerrimis eglandulosis trinervis subtus sericeo-canescentibus supra glabriusculis viridibus: glomerulis densis sessilibus; floribus glabris albis. — Mountains east of Santa Fé, in sunny places; June (in flower), and July, in fruit. Shrub about a foot and a half high and two feet in diameter. — Allied to C. depressus, *Benth. Pl. Hartw. no.* 29; but much more slender, the Thyme-shaped leaves smaller and not glandular, &c. Fruit about as large as in C. Americanus.

* To this species belongs A. Douglasii, *Hook.! Pl. Geyer, l. c. p.* 77. *t.* 6; as already stated in *Suppl. to Fl. N. Amer. p.* 684. Geyer's specimens, like those which I also have from Mr. Spalding, differ only in their larger leaves.

VITACEÆ.

107. Vitis riparia, *Michx.* Rocky precipices of the Rio del Norte; May, in flower.

108. Ampelopsis quinquefolia, *Michx.* Santa Fé to Mora River.

POLYGALACEÆ.

†109. Polygala sanguinea, *Linn.; Torr. & Gray, Fl.* 1. (*Suppl.*) *p.* 670. Low prairies, near Las Vegas, New Mexico; August.

110. P. alba, *Nutt.* (P. Beyrichii, *Torr. & Gray, Fl.* 1. *p.* 130.) From Rabbit's Ear Creek to Willow Bar; August.

LEGUMINOSÆ.

111. Vicia truncata, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 270; the slenderer forms also V. sparsifolia, *Nutt. l. c.* — From Santa Fé east to the head-waters of the Canadian River. — Perhaps an extreme, narrow-leaved form of the next; the lower leaves of which often have linear leaflets.

†112. V. Americana, *Muhl.* (Also V. Oregana, *Nutt. l. c.*) Santa Fé; June.

†113. V. micrantha, *Nutt. l. c.*, var. foliolis minoribus. Deep, rocky ravines of the Rio del Norte; May.

†114. Cicer Arietinum, *Linn.* Santa Fé; in cultivated grounds.

115. Lathyrus polymorphus, *Nutt. Gen.* 2. *p.* 97. (L. decaphyllus, *Pursh.*) Valley of Santa Fé Creek, abundant near irrigating ditches; May, in flower; July, with ripe fruit. Most of the leaves bear quite conspicuous tendrils. The showy flowers are an inch in length, and deep blue in the dried specimens. Mr. Fendler, however, states, in his notes, that they are of different colors, but generally of a deep crimson, which turns into deep blue in drying. He also remarks, that he never observed the plant to be eaten by any domestic animal.

116. L. palustris, *L.*, var. with the smaller and dull-colored flowers of L. myrtifolius. Base of mountains, Santa Fé; June.

†117. Phaseolus leiospermus, *Torr. & Gray, Fl.* 1. *p.* 280. On the Arkansas near Fort Mann; Sept. — The plant is an annual.

†119. P. Helvolus, *Linn.; Torr. & Gray, l. c.* Willow Bar; low, wet bank of the creek; August.

†118. Apios tuberosa, *Mœnch; DC. Prodr.* 2. *p.* 260. Council Grove, Arkansas; August.

† 120. AMPHICARPÆA MONOICA, *Ell. Sk. 2. p. 223.* Council Grove; August.

121. GLYCIRRHIZA LEPIDOTA, *Nutt. Gen. 2. p. 106.* Prairies, in low places, twelve miles east of Council Grove, and in waste places around Santa Fe; July, August.

122. PSORALEA FLORIBUNDA, *Nutt. in Torr. & Gray, Fl. 1. p. 300.* Upper Arkansas to San Miguel, in high prairies; Aug., Sept.

123. P. ARGOPHYLLA, *Pursh, Fl. 2. p. 475; Hook. Fl. Bor.-Am. t. 53.* Between Willow Bar and the Cimarron River; August.

† 124. AMORPHA CANESCENS, *Nutt. Gen. 2. p. 92.* Prairies, around Santa Fé.

125. A. CANESCENS β. LEPTOSTACHYA, *Engelm. Mss.* Woodlands, seven miles west of Las Vegas; August.

126. A. FRUTICOSA, *Linn.* var. (A. nana, *Bot. Mag. t. 2112.* See remarks in *Torr. & Gray, Fl. 1. p. 690, Suppl.*, under A. nana). From 120 miles west of Independence to Pawnee Fork; August (in ripe fruit). Shrub three to five feet high. Ovary with two collateral ovules in this genus, and in Eysenhardtia.

127. DALEA ALOPECUROIDES, *Willd.; DC. Prodr. 2. p. 244.* Low prairies, &c., Santa Fé; also on the Arkansas River; July to September.

128. D. LANATA, *Spreng. Syst. 3. p. 327.* (D. lanuginosa, *Nutt. in Torr. & Gray, Fl. 1. p. 307.*) Low, sandy places in the prairies, near the Cimarron River; August.

129. D. AUREA, *Nutt. Gen. 2. p. 101.* Prairies, from Las Vegas to the Upper Spring on the Cimarron; August.

† 130. D. NANA (*Torr. ined.*): caulibus e basi ramosis diffusis humilibus foliisque sericeo-incanis; foliolis 5 oblongis vel obovatis; spicis oblongis laxiusculis sericeo-villosissimis subsessilibus; bracteis et floribus fere D. aureæ. — Sandy soil, Willow Bar, on the Cimarron; August. Collected in the same region by Fremont in 1845; also by Lindheimer and Mr. Wright in Western Texas in 1847. It appears like a dwarf D. aurea (4 to 6 inches high); but the diffusely spreading stems are repeatedly branched and leafy to the spikes, which are smaller and much less dense.

131. D. LAXIFLORA, *Pursh, Fl. 2. p. 741.* Prairies, on the Cimarron, &c.; August. — D. penicillata, *Moric. Pl. Nouv. Amer. t. 45*, from Texas, appears to be the same species. Dr. Torrey has furnished me with specimens of an allied species from Monterey, Mexico.*

† * DALEA POGONATHERA (sp. nov.): pusilla, glaberrima, perennis; caulibus depressis; stipulis setaceis; foliolis 5–7 oblongo-linearibus subtus rachique grosse nigro-glandulosis; spicis oblongis densifloris; bracteis ovatis carinato-concavis mucronato-acuminatis glabris parce glanduliferis margine scariosis tubum calycis sericeo-villosi laciniis setaceis plumosissimis breviorem æquantibus; petalis purpureis, carina alas et vexillum multo superantibus; staminibus 10. — Around Monterey, Mexico, *Dr. Edwards* and *Major Eaton.* — The specimens (perhaps depauperate) are only 3 or 4 inches high, and might be taken for a starved state of

132. D. FORMOSA, *Torr. in Ann. Lyc. New York*, 2. *p.* 178, and in *Emory's Report, cum ic.* Dry, gravelly hills, in sunny places, Santa Fé; May to June. A dwarf shrub, from half a foot to one foot high; the stem and branches very crooked and intricately entangled.

133. D. JAMESII, *Torr. & Gray, Fl.* 1. *p.* 308. Gravelly hills, in sunny places, from Santa Fé east to McNees Creek; May (in flower) and August (in fruit). — The

D. laxiflora; but the spikes (one inch long) are thicker and denser, the bracts of a different form and not so coriaceous and black-glandular; the petals are purple, and the tenth stamen is present. (While this sheet is passing through the press, I am furnished with specimens from Western Texas, collected by Mr. Wright, who informs me that it occurs rather abundantly from Seguin to the Rio Grande.)

From Dr. Engelmann I have received the following apparently undescribed species of this genus, collected by Dr. Wislizenus, namely: —

DALEA LEUCOSTACHYS (sp. nov.): suffruticosa, humilis, cinereo-puberula; caulibus ramosis glandulis prominulis conspersis; stipulis setaceis caducis; foliolis 5–7 oblanceolatis cuneato-oblongisve obtusis petiolulatis glabratis utrinque (supra creberrime) glanduloso-punctatis; spicis ad apicem paniculatis pedunculatis cylindricis densis; bracteis subulatis calyce pubescente breviter 5-fido brevioribus deciduis; petalis albis, vexillo suborbiculari alas et carinalia consimiles fere æquante. — At Cosiquiriachi, in the Sierra Madre, *Dr. Wislizenus;* flowering in September. — Shrub 2 or 3 feet high; branches leafy to the top, where it bears several handsome spikes (which may be likened to those of Eysenhardtia) of white flowers: the petals are two or three lines in length, besides the slender claw. Leaflets one half to three fourths of an inch long. In a single flower I found six petals and two pistils. The claws of the wings and keel-petals are adnate to the stamineal column only at the base (not to the middle, as the genus is characterized); and the insertion is little higher in the following and in several other species. The anthers are commonly tipped with a gland, which in this species is remarkably conspicuous.

D. WISLIZENI (sp. nov.): sericeo-villosa; caulibus seu ramis gracilibus erectis; stipulis setaceis; foliolis 7–9-jugis parvulis (2 lin. longis) oblongis obtusiusculis pulchre sericeis subtus cauleque parce nigro-glanduliferis; spicis solitariis pedunculatis oblongis; bracteis lanceolato-setaceis calycibusque æquilongis sericeo-villosissimis; laciniis calycis tubo longioribus subulato-aristatis basim versus utrinque unisetulosa; petalis albo-purpureis omnibus juxta apicem glandula lineari notatis, carina alas dimidio vexillum multo superantibus. — Llanos, in the Sierra Madre, west of Chihuahua, *Dr. Wislizenus;* flowering in October. — Stems or branches a foot high. Flowers showy, one third of an inch long.

D. SCOPARIA (sp. nov.): cano-tomentulosa deinde glabrata, undique pustulato-glandulifera; caulibus (basi fruticosis?) ramosissimis gracilibus rigidis inferne denudatis; foliis ramealibus plerumque simplicibus spathulato-linearibus subsessilibus margine revolutis parvulis rariusve trifoliolatis; stipulis minimis; capitulis 5–10-floris laxiusculis pedunculatis corymboso-paniculatis; bracteis minimis ovatis caducis; calycibus incanis breviter 5-dentatis gibboso-arcuatis; petalis pulchre violaceis omnibus ad apicem uniglandulosis subæquilongis. — Jornado del Muerto, between Santa Fé and El Paso del Norte, *Dr. Wislizenus;* August. — A remarkable, Broom-like species; the rigid stems, &c., roughened all over with large, pustulate glands; the diffuse branchlets terminated by small and globular heads of (in the specimens) deep violet flowers. Petals two lines long; the oblong-oval vexillum as long as the keel.

stems of this curious dwarf species are cæspitose from a branched and tortuous caudex. The corolla, which is at first yellow, appears to turn purple in fading.

134. PETALOSTEMON VILLOSUM, *Nutt. Gen. 2. p. 85*; *Torr. & Gray, Fl. 1. p. 310.* Sandy soil, between the crossing of the Cimarron and the Middle Spring; August.

135. P. GRACILE, *Nutt. in Jour. Acad. Philad. 7. p. 92.* Santa Fé; on the Cimarron; and west of Independence, Missouri. — Some of the specimens, I know not from which locality, have awn-pointed or cuspidate bracts, which are longer than the flower-buds, and are scarcely, if at all, distinguishable from P. candidum, to which the whole species is perhaps too closely related.

† 136. P. CANDIDUM, *Michx. Fl. 2. p. 49. t. 37. f. 1.* Prairies, near the upper ferry of the Kansas River.

† 137. P. VIOLACEUM, *Michx. Fl. 2. p. 50. t. 37. f. 2*: — a pubescent variety; the calyx very silky-villous. Five miles west of Las Vegas, New Mexico; August.

138. P. VIOLACEUM, *Michx.*: — a more slender glabrous form, with shorter points to the bracts; otherwise nearly as the last. Between Willow Bar and Middle Spring, Cimarron, in sandy soil.

† 139. P. MACROSTACHYUM, *Torr. in Ann. Lyc. New York, 2. p. 176*; *Torr. & Gray, Fl. l. c.* A single specimen, with white flowers (those of P. ornatum, *Dougl.* are violet). Prairie, 18 miles west of Lower Spring, Cimarron; August.*

140. TRIFOLIUM INVOLUCRATUM, *Willd.*; *DC. Prodr. 2. p. 204*; *Benth.! Pl. Hartw. no. 50*; non *Torr. & Gray.* Poñi Creek, between Bent's Fort and Santa Fé, and on Santa Fé Creek, near the water. — Well distinguished from T. tridentatum, *Lindl.*, by the longer calyx-teeth and corolla. The only species of the involucrate section which has been found (now for the first time in so high a latitude) east of the Rocky Mountains or the Andez.

141. MELILOTUS PARVIFLORA, *Desf.* Low grounds, around Santa Fé.

142. MEDICAGO SATIVA, *Linn.* Fields, around Santa Fé. — This and the last were undoubtedly introduced from Europe. From Dr. Gregg's collections, both appear to be naturalized throughout Northern Mexico.

143. HOSACKIA PURSHIANA, *Benth.* High prairies, Upper Arkansas.

† 144. ASTRAGALUS? or PHACA? A single specimen, without fruit. Between the Rio Colorado and Rock Creek; August.

† 145. ASTRAGALUS CANADENSIS, *Linn.* On the Kansas River, one hundred miles west of Independence.

* Dalea agastachys, *Moric. Pl. Nouv. Amer. t. 44* (1839) is Petalostemon obovatum, *Torr. & Gray.*

146. A. DIPHYSUS (sp. nov.) : subglaber, depressus, caulibus numerosis e radice perpendiculari crassa adsurgentibus ; stipulis triangularibus acuminatis scariosis basi petioli adnatis ; foliolis 9 – 10-jugis carnosulis obovato-oblongis sæpe retusis ; pedunculis folium æquantibus ; racemo spicato densifloro brevi ; pedicellis bractea ovato-subulata persistente calyceque cylindraceo brevioribus ; corolla cærulea ; leguminibus membranaceis inflatis ovatis acuminatis sursum arcuatis suturis utrinque introflexis subdidymis complete bilocellatis polyspermis nitidis. — Plains, around Santa Fé, in red sandy soil, of a low and depressed growth, but forming patches one or two feet in diameter ; April to May. Mr. Fendler further remarks, that he never observed this plant to be eaten by any animal whatever. — This species produces a thick cluster of stems, 6 to 10 inches high, from the same fleshy root, and in appearance is not unlike A. caryocarpus and A. trichocalyx, but is smoother, having only sparse and minute appressed hairs on the stems and petioles, and sometimes on the midrib of the otherwise glabrous leaflets ; and the flowers are smaller (barely half an inch long). The pods are remarkably different, being of a thin and membranaceous or papery texture, didymous and inflated, about an inch long at maturity, pointed and incurved. It is equally distinct from the little-known A. pachycarpus, *Torr. & Gray;* which bears a legume that has evidently been succulent before ripening, and when dry exhibits the same thickened and cellular walls as those of A. caryocarpus and A. trichocalyx, with which it should be associated.

147. A. DIPHYSUS β. ALBIFLORUS. With the preceding, apparently differing only in the white flowers. The specimens show no fruit.

148. A. CYANEUS (sp. nov.) : subcaulescens ; caudice multicipiti ; stipulis triangularibus vel subulato-lanceolatis ; foliolis 9 – 14-jugis ovato-rotundis ovalibus oblongisve cum petiolis pube minuta strigulosa appressa utrinque griseo-canescentibus ; pedunculis scapoideis folia subæquantibus angulatis 8 – 12-floris ; pedicellis brevissimis bracteam subulatam æquantibus ; calyce pilis griseo-nigricantibus appresso-pubescentibus, dentibus subulato-setaceis tubo cylindrico dimidio brevioribus ; corolla cyanea ; leguminibus cartilagineis puberulis rugulosis oblongo-linearibus acuminatis sursum curvatis turgidis polyspermis sutura dorsali profunde sulcata introflexa incomplete bilocellatis, sutura ventrale extus prominente. — Santa Fé, on gravelly hills and low mountains among rocks ; April, May. — A larger plant than A. Missouriensis, which the species most resembles in habit, foliage, and flowers ; the mode of growth much as in the preceding, but almost acaulescent. Leaves crowded at the summit of the branches of the caudex or on the abbreviated flowering stems, 3 to 6 inches long ; the leaflets one fourth, or sometimes nearly one half, an inch in length, hoary with a close and fine strigulose pubescence. The peduncles or scapes are stout and erect, 4 to 8 inches long in fruit. The flowers are almost an

inch long, deep blue, or perhaps violet, and showy. The stout and thickish pods are ascending, an inch and a half in length, one fourth of an inch broad, at first scymetar-shaped, but at length turgid and dilated, with a very broad and deep groove on the convex side from the strong introflexion of the dorsal suture, while the ventral shows a salient ridge and is not at all introflexed. — In some respects this species accords with A. humilis, *Geyer (Hook. in Lond. Jour. Bot. l. c.*, — a name which, by the way, is preoccupied by Bieberstein); but that is said to have an ovate fleshy legume, and evidently belongs to the same section as A. caryocarpus. May it not be A. pachycarpus?

149. A. Missouriensis, *Nutt. Gen. 2. p. 99.* (A. melanocarpus, *Richards.! in Frankl. Jour.; Hook.! Fl. Bor.-Am. 1. p. 150.* Stony hills, Rio del Norte and at Santa Fé; May. — The mature legume is elliptical, compressed, margined, and with neither suture manifestly introflexed.*

† 150. A. Hypoglottis, *Linn.; Hook. & Arn. Bot. Beech. p. 334.* (A. goniatus, *Nutt.!*) Prairie, on the Mora River; August.

† 151. A. sp. Dry, gravelly hills near Santa Fé; May. A dwarf, canescent species, of which only a single small specimen was collected, in fruit only; so that it cannot be safely described, if new. The legumes are arcuate, nearly an inch long, canescently puberulent, deeply grooved at the dorsal suture, and 2-celled.

† 152. A. mollissimus, *Torr. in Ann. Lyc. New York, 2. p. 178, & Fl. N. Am. 1. p. 337.* Between McNees Creek and Cold Spring; August. — In fruit only; apparently a dwarfish form, with very densely silky-villous foliage. Dr. Gregg gathered it near Chihuahua and Lieut. Abert near Bent's Fort, on the Arkansas.

† 153. A. mollissimus, *Torr. l. c.* Ojo de Bernal; August. — In fruit and flower. Leaves, &c., much larger than in the last, and more nearly agreeing with the description of this species. The largest leaflets are even an inch and a half in length. The stipules cohere for nearly half their length with the base of the petiole.

† 154. Oxytropis Lambertii, *Pursh; Torr. & Gray, Fl. 1. p. 339*: — a variety with 7 to 13 leaflets and rather few and scattered flowers; nearly the same as No. 77 of Geyer's Oregon collection. Prairies, Mora River; August.

* A. distortus, *Torr. & Gray*, is found by Dr. S. B. Mead, in Mason county, Illinois. The mature legumes are longer than in the original Texan specimens, strongly arcuate rather than abruptly bent, and fully three fourths of an inch long, following the curvature, but much smaller than those of A. obcordatus. Those of the latter are somewhat laterally compressed, with an acute and salient ventral suture, as described in the *Flora of N. America*, and the dorsal suture merely sulcate, but little introflexed. In the former, the fully ripe legumes of Dr. Mead's plant are obcompressed, strongly sulcate along both sutures, with the dorsal so much introflexed as to become nearly or quite 2-celled.

† 155. O. CAMPESTRIS β. SPECIOSA, *Torr. & Gray, Fl. l. c.; Hook! Lond. Jour. Bot.* 6. *p.* 212. Between Rabbit's Ear and McNees Creeks; August. — Probably quite distinct from the European O. campestris.

156. ASTRAGALUS NUTTALLIANUS β. TRICHOCARPUS, *Torr. & Gray, Fl.* 1. *p.* 334. Bank of the Rio del Norte; May.

157. PHACA FENDLERI (sp. nov.): parce striguloso-puberula; caule gracili flexuoso angulato; foliolis 7–11-jugis oblongo-linearibus obtusis glabratis petiolulatis (¼–1 unc. longis); stipulis triangulatis parvulis; racemis longe pedunculatis patentibus spiciformibus 10–20-floris laxis folium superantibus; floribus purpureis patulis; calycibus nigro-pubescentibus; leguminibus deflexis oblongis rectis turgidis fere glabris estipitatis. — Woodlands, in the mountains, between Santa Fé and Pecos; August, 1847. — Plant a foot high. Peduncles 5 or 6 inches long; half the length occupied by the flowers when developed: these are one third of an inch long, apparently violet-purple, on very short pedicels, and subtended by minute bracts. Calyx campanulate, with short triangular-subulate teeth, pubescent with minute dark hairs. Legume (immature) three fourths of an inch long, two lines broad, very minutely puberulent with white hairs, multiovulate, several-seeded. — Evidently allied to P. flexuosa, *Hook.*, and P. elongata, *Hook.*, perhaps too near to the former: but the flowers are larger, the calyx minutely black-haired and not sericeous, the legumes apparently membranaceous, and the whole plant almost glabrous.

† 158. Apparently a mere variety of the next, with broader and more retuse leaflets.

159. P. GRACILENTA (sp. nov.): perennis, canescenti-pubescens, humilis; caule erecto flexuoso superne ramoso; stipulis subulatis; foliis breviter petiolatis; foliolis 7–9-jugis cuneato-linearibus obtusissimis retusisve supra glabratis; pedunculo 10–20-floro folium æquante vel superante; calyce nigro-pubescente, dentibus subulatis brevibus; leguminibus chartaceis oblongis inflatis rectiusculis utrinque obtusis estipitatis cinereo-puberulis. — Bare, rocky hills, Santa Fé; April to June. — The specimen I possess is in fruit only, about 8 inches high, with a slender, flexuous stem. The flowers are said to be "pale purple." The legumes are three fourths of an inch long, terete, straight or slightly incurved, and one fifth of an inch in diameter. In habit and foliage it is much like Phaca annua of Geyer, and P. triflora, *DC.* (which Dr. Gregg has sent from Chihuahua, &c.); but the peduncles are larger, and the pods smaller, more chartaceous, and much less inflated.

160. P. MACROCARPA (sp. nov.): cinereo-puberula; caule crasso fistuloso ramoso striato-angulato adscendente; stipulis triangulari-lanceolatis distinctis; foliis rigidiusculis 1–5-foliolatis vel summis non folioliferis, rachi filiformi complanata, foliolis filiformi-linea-

ribus remotis; pedunculis folio longioribus; racemis multifloris; floribus decurvis majusculis (ochroleucis seu albidis); leguminibus elongatis lanceolatis membranaceis glabris turgidis rectis utrinque acutatis in stipitem calyce cylindraceo longiorem attenuatis polyspermis. — Rocky declivities, near Santa Fe; June. — Root apparently perennial. Plant one or two feet high, much branched, cinereous with a very minute appressed pubescence. In appearance the foliage is intermediate between that of P. pectinata and P. podocarpa; but the leaflets are much fewer than in either; more frequently only two or three, scattered along the flattened rachis. They are distinctly articulated, from half to three fourths of an inch long and about half a line wide. Flowers nearly as in P. pectinata, but the calyx is not dark-haired. The pods (which are not quite mature) are two inches long, including the stipe, apparently terete, and two lines in diameter, of a thin membranaceous texture, with neither suture introflexed, about 20-seeded.

✓ 161. P. PICTA (sp. nov.): annua, humilis, undique strigoso-incana; caulibus ramosis diffusis; stipulis triangulari-subulatis majusculis; foliolis 4–7-jugis anguste linearibus obtusis; racemis folio subbrevioribus 7–15-floris; dentibus calycis setaceis tubo vix brevioribus (corolla rosea vel albida, carina sæpius purpureo tincta); leguminibus ovalibus obtusis rectis membranaceis inflatis glabris purpureo-pictis breviter stipitatis oligospermis. — Loose, sandy soil on the banks of the Rio del Norte, especially among low shrubs; April (in flower) and June (in fruit). — Allied to P. longifolia, P. annua, *Geyer*, P. Hookeriana, &c., and with the same beautifully mottled legumes. The appressed hairs, which render the plant quite hoary throughout, are attached by a point below their middle. Stems 5 to 9 inches high, often branched from a straggling or creeping base, which has apparently been covered with loose sand. Leaflets one half to three fourths of an inch long, sometimes almost filiform. Flowers spreading, one fourth of an inch long, the young fruit pendulous. Pods three fourths of an inch long, very obtuse, straight, on a stipe about the length of the calyx. The flowers are twice as large as those of P. gracilenta, no. 159; which are pubescent and not stipitate nor mottled.

† 162. DESMODIUM SESSILIFOLIUM, *Torr. & Gray, Fl.* 1. *p.* 363. One hundred miles west of Independence, Missouri.

† 163. D. DILLENII, *Darlingt. Fl. Cest. p.* 414; *Torr. & Gray, Fl. l. c.* With the last.

164. LESPEDEZA CAPITATA, *Michx.* Dry prairies, Kansas River.

† 165. L. REPENS, *Torr. & Gray, l. c. p.* 366. Near Fort Leavenworth.

✓ 166. LUPINUS DECUMBENS, *Torr. in Ann. Lyc. New York*, 2. *p.* 191. Var. ARGOPHYLLUS: caule foliisque argyreo-sericeis, supra viridiusculis. — Plains, around Santa Fé; May to June, in flower; June to Aug., in fruit. — A foot high, a silvery white species; more so than in the original specimens of L. decumbens, which, imperfect as they are, I

am confident belong to the same species with ours. It is a very handsome plant, with flowers as large as in L. perennis, and apparently light blue. A characteristic of the species is the saccate, almost spurred, base of the calyx, which is quite as conspicuous as in L. laxiflorus, next to which it should be placed. The same plant was gathered near the sources of the Platte in the first expedition of Col. Fremont, and forms part of what was called L. ornatus in the Botanical catalogue of that expedition.

167. Same as the last (and growing with it), with the flowers light rose-color. — The flowers in the dried specimen appear to be ochroleucous; perhaps it is the L. argenteus of Pursh (which has not been really identified); but it cannot be the L. argenteus of Agardh.*

† 169. L. DECUMBENS, *Torr.;* with the leaflets glabrous above; the flowers apparently pale, as large as those of no. 166 and no. 167. Poñi Creek, in low prairies.

168. L. LAXIFLORUS, *Dougl.?* with oblong-lanceolate, almost entirely glabrous leaflets. — Valley of Santa Fé Creek, in the mountains; June, July.

170. THERMOPSIS MONTANA, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 388. Foot of mountains, in low, moist places, valley of Santa Fé Creek, five miles above Santa Fé; May, June. — The wings and keel often acquire a blue tinge in drying; as in specimens from Oregon, by Mr. Spalding, of T. fabacea, *Hook! in Pl. Geyer*, which are not well to be distinguished from this species.

† 171. SOPHORA SERICEA, *Nutt. Gen.* 1. *p.* 280. Prairies, from the Mora River to Cold Spring, on the Cimarron; August.

† 172. CERCIS CANADENSIS, *Linn.* Council Grove; in the creek bottom.

173. HOFFMANSEGGIA JAMESII, *Torr. & Gray, Fl.* 1. *p.* 393. Near the ford of the Cimarron River; Aug. — In ripe fruit, with some flowers.

† 174. CASSIA CHAMÆCRISTA, *Linn.* Cimarron River; August.

† 175. C. MARILANDICA, *Linn.* Council Grove; August.

† 176. KENTROPHYTA MONTANA, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 353. Gravelly hill-sides, Santa Fé; June.

† 177. SCHRANKIA ANGUSTATA, *Torr. & Gray, Fl.* 1. *p.* 400. Council Grove; August.

178. DESMANTHUS BRACHYLOBUS, *Benth. in Hook. Jour. Bot.* 4. *p.* 358. (Darlingtonia, *DC., Torr. & Gray, l. c.*) On the Cimarron River, &c.

179. D. JAMESII, *Torr. & Gray, Fl.* 1. *p.* 402. Santa Fé to Rayado Creek, on the route to Bent's Fort; in gravelly soil.

* No. 390 of Geyer's Oregon Collection was given as Lupinus albicaulis by Hooker, probably by a slip of the pen, as my specimens are L. leucophyllus, *Lindl.*, with one of L. sericeus?

† 180. Calliandra? herbacea (*Engelm. Mss.*): "caule humili erecto flexuoso adpresse piloso; stipulis lanceolatis nervosis; foliis longe petiolatis; pinnis 3–4-jugis; foliolis 20–30 obliquis oblongis obtusiusculis ciliatis supra glabris subtus laxe reticulatis adpresse pilosis; capitulis florum binis folio brevioribus, pauci- (8–10-) floris; calycibus tubulosis 4–5-dentatis, dentibus tubo subbrevioribus ciliatis; tubo corollæ calyce triplo longiore dentibus obtusiusculis apice parce pilosis; staminibus 25–30 corollam longe superantibus. — Between San Miguel and Las Vegas; flowering in August. — Plant apparently perennial, 6 inches high: leaves with petioles 3 inches long: leaflets 3 lines long: heads about one inch in diameter, on peduncles of one inch in length. Flowers polygamous: a fertile flower which I examined had four calyx and four corolla teeth, a sterile one, five teeth: stamens united at the base, more so in the fertile flower. Ovary elongated, with many ovula and the tumid sutures glabrous." *Engelm.* — There is another apparently new species in the collections of Wislizenus and Gregg.*

181. Mimosa borealis (sp. nov.): fruticosa, erecta, glaberrima; ramis aculeis infra stipularibus solitariis validis patentissimis rectiusculis armatis; foliis parvis, pinnis 1–2-jugis petiolum æquantibus, foliolis 4–5-jugis ovalibus vix inæquilateralibus crassiusculis (floribus ignotis); leguminibus oblongis stipitatis 2–4-spermis glabris margine sparsim uncinato-aculeatis, valvulis in articulos 2–4 secedentibus. — Hill-side, Upper Spring, on the Cimarron; August. — The specimens have ripe fruit, but no flowers. They appear to belong to an upright shrub. The branches are armed with very stout and slightly hooked, scattered, infrastipular spines. The common petiole is only half an inch in

* C. Chamædrys (*Engelm. Mss.*): "fruticosa, humilis; ramulis petiolisque brevibus eglandulosis pubescentibus; foliis 2–3-jugis rarius 1-jugis; foliolis 6–12-jugis minutis ovatis obtusis seu acutiusculis supra glabris subtus pilosis; stipulis subulatis rigidis erectis subpersistentibus; capitulis breviter pedunculatis singulis binisve pauci- (4–8-) floris; floribus hermaphroditis; calyce campanulato subinæqualiter 5-dentato, dentibus obtusis pilosis; corolla tubuloso-campanulata calycem ter quaterve superante ad medium 5-fida extus parve pilosa (purpurea), lobis lanceolatis acutis subæqualibus; staminibus polyadelphis basi in tubum connatis elongatis tenuissimis circiter 35; ovario lineari-lanceolato suturis incrassato glaberrimo; stylo tenuissimo capillaceo stamina superante; stigmate capitato; legumine lineari-lanceolato stipitato acuminato (immaturo) albo-sericeo marginibus valde incrassatis subnudo. — Chihuahua, *Dr. Wislizenus*, *Dr. Gregg;* flowering in April. — Stems squarrose, much branched, 3 to 12 inches high, stout. Leaves 4 to 8 lines long: leaflets ¾ to 1 line long. Peduncles 3 to 4 or 5 lines long. Stamens an inch long. Legume 1½ to 2 inches long, ¼ inch wide, white silky, while the ovary is perfectly glabrous! — The specimens of Dr. Wislizenus, from Bachimba, are smaller, more branched; the leaflets smaller, obtuse, more hairy, and not more than bijugate, the lobes of the corolla recurved. Dr. Gregg collected in the Cañon of Ojito larger specimens, with often acutish leaflets, and larger flowers, with the lobes of the corolla erect. — Apparently near C. Californica and C. Xalapensis, *Benth.*, but well distinguished by the very small leaflets, &c." *Engelm.*

length, and usually bears a single pair of small pinnæ; when there are two pairs, these are somewhat approximate. The leaflets are only about one line in length, thickish, obscurely veiny, and perfectly smooth. The joints of the flat pod are one fourth of an inch in diameter. — The locality is somewhat north of lat. 37°; consequently this is the most northern species of the genus known. It is apparently quite distinct from any of those described in Mr. Bentham's Synopsis (in *Hook. Jour. Bot. vol.* 4). — As this sheet is going to press, I have the opportunity of examining flowers of this species, sent me by Dr. Engelmann from a specimen gathered on the Upper Canadian in April, 1848, by Mr. Gordon. They have a truncate purplish calyx, five spatulate-oblong petals which are separate to the base, and ten distinct stamens.

ROSACEÆ.

† 182. Prunus Americana, *Marsh.; Darlingt. Fl. Cest. p.* 287. Rock Creek bottom.

183. Armeniaca vulgaris, *Lam.* A naturalized tree along the valley of Santa Fé Creek, near dwellings; flowering in April.

† 184. Prunus domestica, *Linn.* Santa Fé; naturalized around dwellings.

185. Cerasus demissa, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 411. Steep, rocky banks of Santa Fé Creek; June; in fruit, July. — The fruit appears to be larger than our choke-cherry; and it is fine-flavored, according to Mr. Spalding, who sends it from Oregon.

† 186. C. Virginiana, *DC.* Foot of rocks, on the Mora River; in fruit only; Aug.

187. Spiræa opulifolia, γ. pauciflora, *Torr. & Gray! Fl.* 1. *p.* 414. (S. monogyna, *Torr.! in Ann. Lyc. N. Y.*) Foot of hills, Santa Fé Creek; June, July. Shrub a foot high. — Very probably a distinct species. The ovaries are more commonly two in number.

188. S. dumosa, *Nutt! Mss.; Hook. Lond. Jour. Bot.* 6. *p.* 217. Steep mountain-sides, upper part of Santa Fé Creek; July. Shrub about 4 feet high. — This is the S. discolor of Torrey in *Ann. Lyc. New York* (James's Collection), and a good species: but the original S. discolor, *Pursh*, I believe to be only S. ariæfolia; as certainly is a plant of Menzies so named by Pursh in Herb. Lambert.

189. S. (Petrophytum) cæspitosa, *Nutt.! in Torr. & Gray, Fl. l. c.* Rocky precipices on the Rio Colorado (i. e. the Upper Canadian); August.*

190. Geum macrophyllum, *Willd. Enum.* 1. *p.* 557; *Torr. & Gray, Fl.* 1. *p.* 421. Along the banks of Santa Fé Creek; May to July.

† 191. G. Virginianum, *Linn.* Council Grove, Missouri.

* The æstivation of the petals in Gillenia is not imbricative as in the rest of the family, but *convolute*.

† 192. G. RIVALE, *Linn.* Margins of Santa Fé Creek, in the mountains; June.

193. FALLUGIA PARADOXA, *Torr.! in Emory's Report, t. 2.* (F. Mexicana, *Walp. Repert. 2. p. 46.* Sieversia paradoxa, *Don in Linn. Trans. p. 326. t. 22.* — Rayado Creek, between Bent's Fort and Santa Fé; and on the Rio del Norte, on steep banks; May, in flower; October, in fruit. Shrub 2 to 5 feet high.

194. CERCOCARPUS PARVIFOLIUS, *Nutt. in Torr. & Gray, Fl. 1. p. 427.* — Cliffs of Santa Fé Creek, in the mountains; July, in fruit. Shrub 8 to 10 feet high. The leaves in these fine fruiting specimens are from an inch to an inch and a half in length; the tails of the fruit nearly three inches long and densely plumose.

195. AGRIMONIA EUPATORIA, *Linn.;* var. Banks of Santa Fé Creek; July.

† 196. A. EUPATORIA, *Linn.* Near Fort Leavenworth; August.

197. POTENTILLA FISSA, *Nutt. β. MAJOR, Torr. & Gray, l. c.* Perhaps a variety of P. arguta. Rocky places, valley of Santa Fé Creek; June, July.

198. P. DIFFUSA (sp. nov.): humilis; caulibus e caudice perpendiculari crasso adsurgentibus incano-villosis subnudis cito dichotomis et in cymam effusam diliquescentibus; foliis radicalibus pinnatim 5 – 7-foliolatis, foliolis oblongis approximatis summis confluentibus pectinatim inciso-serratis obtusissimis supra subsericeis viridibus subtus cano-tomentosis mollissimis; caulinis 1 – 2 foliolis segmentisve 3 – 5 lanceolatis, cæteris ad bracteas stipulis ovato-lanceolatis fulcratas reductis; pedicellis gracillimis; calycis cano-villosi laciniis ovato-acuminatis bracteolis lanceolatis obtusis sublongioribus petalis aureis obcordatis paulo brevioribus; carpellis lævissimis. — Moist soil, along Santa Fé Creek; June. — This species apparently should stand between P. effusa, *Dougl.* (of which I have present access to no specimen for comparison) and P. Pennsylvanica, ε. Hippiana. The flowering stems are 6 to 8 inches high, scape-like, bearing only a single well-formed leaf near the base, and beginning a little above to divide into the effuse, several times dichotomous cyme. Stipules entire, or nearly so. Pedicels 1½ inch long. Flowers rather smaller than in P. Pennsylvanica.

199. P. CRINITA (sp. nov.): humilis, multiceps e radice crassa, albo-villosa; caulibus adscendentibus circ. 3-foliatis apice laxe paniculato-cymosis; stipulis ovato-lanceolatis acuminatis majusculis; foliis pinnatis, radicalibus 11 – 15-, caulinis 5 – 7-foliolatis; foliolis oblongis confertis grosse dentatis supra subglabratis subtus rachique pilis longis albis comptis villosis; calycis laciniis ovato-acuminatis bracteolas oblongo-lanceolatas subsuperantibus petalis obcordatis aureis paulo brevioribus; acheniis glaberrimis; receptaculo comoso. — Along Santa Fé Creek, and at the foot of hills, in sunny places; July. — Stems 6 inches high. Radical leaves 2 inches long, including the petiole: leaflets half an inch long; the surface soon smooth or nearly so; the lower clothed with long and

straight, incumbent, white hairs, which give the plant a remarkable appearance. The flower is as large as that of P. Pennsylvanica. The receptacle is very villous.

200. P. ANSERINA, *Linn.* Moist meadows, along Santa Fé Creek; May, June.

†201. P. PENNSYLVANICA, *Linn.*, between *a.* and *β. Torr. & Gray, Fl.* 1. *p.* 438. Hill-sides, Mora River; August, in fruit.

202. P. PENNSYLVANICA, var. CONFERTA. A dwarf, very canescent-silky form, six or eight inches high, agreeing with P. conferta, *Bunge! in Ledeb. Fl. Alt.* Valley of Santa Fé Creek, in the mountains; June, July.

203. P. RIVALIS, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 437. Along the margins of Santa Fé Creek; June, July.—Appears to be exactly Nuttall's plant: allied to P. supina.

†204. P. FASTIGIATA, *Nutt. l. c.* Valley of Santa Fé Creek; June.

205. P. NORVEGICA, *Linn.* Valley of Santa Fé Creek, in the mountains; June, July.

206. FRAGARIA VIRGINIANA, *Ehrh.; Torr. & Gray, Fl.* 1. *p.* 448. Sides of the mountains, Santa Fé Creek, socially, and intermixed with the next; April to June.

207. F. VESCA, *Linn.; Torr. & Gray, l. c.* Similar situations to the preceding, though not generally so high up on the mountains; April to May.

208. RUBUS NUTKANUS, *Moçino; Torr. & Gray, Fl.* 1. *p.* 450: var. PARVIFOLIUS. Shady banks of Santa Fé Creek; June, in flower; July, in fruit. — These are small-leaved specimens, resembling those from Michilimackinac (R. parviflorus, *Nutt.*); the leaves, indeed, only 2 or 3 inches in diameter; the flowers large in proportion. From Lake Superior, where the plant abounds, I have specimens precisely like those of the western coast.

209. R. STRIGOSUS, *Michx. Fl.* 1. *p.* 297. Santa Fé Creek.

210. ROSA BLANDA, *Ait.; Torr. & Gray, Fl.* 1. *p.* 459. Margins of Santa Fé Creek; June.

†211. R. BLANDA, *β. Torr. & Gray, l. c.* Banks of Rock Creek, New Mexico; August, in fruit.

†212. R. WOODSII, *Lindl. Ros. p.* 21, *& Bot. Reg. t.* 976? Rock Creek and Mora River; August, in fruit.

213. AMELANCHIER CANADENSIS, δ. ALNIFOLIA, *Torr. & Gray, Fl.* 1. *p.* 473. Valley of Santa Fé Creek in the mountains; July, in fruit.

LYTHRACEÆ.

214. AMMANNIA LATIFOLIA, *Linn.; Torr. & Gray, Fl.* 1. *p.* 480. Near Council Grove; August to September.

215. Lythrum alatum, *Pursh, Fl.* 1. *p.* 334. Council Grove, and near Fort Leavenworth; August to September.

ONAGRACEÆ.

216. Epilobium angustifolium, *Linn.* Ravines in the valley of Santa Fé Creek, in the mountains; June, July.

217. E. coloratum, *Muhl.; Torr. & Gray, Fl.* 1. *p.* 489. Santa Fé Creek, and Raton Creek, in the mountains; June to September.

218. Œnothera biennis, var. hirsutissima. Valley of Santa Fé Creek, in the mountains; June. Plant 2 to 3 feet high.*

†219. Œ. biennis, *Linn.* Near Council Grove.

†220. Œ. biennis, ζ. canescens, *Torr. & Gray, l. c.* Near Independence, Missouri.

221. Œ. sinuata, γ. hirsuta, *Torr. & Gray, Fl.* 1. *p.* 494. Hill-side, near a field, Santa Fé; July.

222. Œ. coronopifolia, *Torr. & Gray! Fl.* 1. *p.* 495. Valley of Santa Fé Creek, in various localities, on soil recently thrown up along the side of irrigating ditches, and on old ant-hills; May to July. — A span to nearly a foot high. Also gathered between the Platte and Santa Fé by *Lieut. Abert.* To this I now refer the imperfect fragment in Dr. James's collection which in the *Flora N. Amer.* was cited under Œ. pinnatifida, and from which the character "capsule somewhat tapering towards the apex" was derived. A distinguishing character of Œ. coronopifolia, which perfectly confirms the species, is found in the capsule, which is ovoid-cylindraceous or oblong, turgid, only two thirds or not more than three fourths of an inch long, two lines thick, minutely canescent, and usually sparsely strigose-hirsute. The seeds are oval, striate and punctate, large for the size of the pod, and much larger than in the next species. The petals turn to a deep pink or red in drying.

223. Œ. pinnatifida, *Nutt. Gen.* 1. *p.* 245. Gravelly soil at Santa Fé, and on

* There is a remarkably distinct species of this section in Dr. Gregg's collection, which may be characterized as follows:—

Œ. (Onagra) macrosceles (sp. nov.): glabra; caule gracili erecto; foliis crassiusculis lævibus dense ciliatis subintegerrimis, radicalibus (7 – 12-uncialibus) spathulato-lanceolatis in petiolum longe attenuatis, caulinis subsessilibus lanceolato-oblongis; tubo calycis prælongo (5-unciali) gracili ovario lineari 5-plo laciniis plus triplo longioribus; stylo petalas dilatato-cuneiformes æquante stamina superante; stigmatibus prælongis. — Marshy borders of springs, Vara de San José, Ojo de San Bernardo, and Pelayo, Northern Mexico, *Dr. Gregg.* — This species, which should probably stand next to Œ. Jamesii, is remarkable for its smoothness, except the ciliation of the leaves, and for the length of the calyx-tube. The corolla is 3 inches or more in diameter, yellow, turning slightly rose-color in the dried specimens. The anthers are half an inch long, and the stigmas about the same length. The fruit is unknown; the ovary is cylindrical and slender.

the Rio del Norte; May. — Corolla often 2 inches in diameter, pure white turning to rose-color. Some of the specimens are only two or three inches high, and just beginning to blossom; the radical leaves oblong or spatulate and entire: others are a foot high, with widely spreading or decumbent branches; the leaves deeply sinuate-pinnatifid or incised; the lobes mostly triangular or lanceolate, acute. The calyx is merely canescent, or sprinkled with a few hirsute hairs. The capsules are longer and more slender than in any allied species (an inch long, quadrangular, *Nutt.*), frequently an inch and a half or even two inches in length and of the same diameter (one line) throughout, truncate, prismatic, porrected, or at length decurved or contorted. Seeds oblong, smooth, small.

224. Œ. PINNATIFIDA, var. INTEGRIFOLIA. Santa Fé, and along the Cimarron, in gravelly soil or sand; June to August. — The leaves are oblong or lanceolate, often conspicuously mucronate, repand-denticulate, or with here and there a distinct salient tooth, both sides more or less canescent with a minute appressed pubescence. The flowers, and the elongated, slender, prismatic capsules, are just as in no. 223; of which it is no doubt a variety, and to which it sustains the same relation that Œ. humifusa, *Nutt.*, and Œ. minima, *Pursh*, do to Œ. sinuata (*Torr. & Gray, Fl.* 1. *p.* 491). Precisely the same form was gathered on the Platte in Fremont's first expedition; and on one specimen I notice that the petals, instead of turning uniformly reddish or in blotches with age or in drying, are minutely punctate with red dots. While some forms gathered in Fremont's third expedition pass by their foliage directly into the ordinary Œ. pinnatifida (although, indeed, they sometimes exhibit running or horizontal roots), others, with narrower leaves, appear to run into Œ. albicaulis, *Nutt.*; and still others, becoming nearly or quite glabrous and smooth, make a perfect transition into Œ. pallida, *Lindl.*, the narrow-leaved forms of which I cannot distinguish from Œ. albicaulis.

†225. Œ. SPECIOSA, *Nutt.* Near Council Grove, &c.; August.

†226. Œ. FRUTICOSA, *Linn.*; var. Council Grove; August.

227. Œ. CANESCENS, *Torr. & Frem.! in Frem. 2d Exped. p.* 315. (Œ. guttulata, *Geyer in Hook. Lond. Jour. Bot.* 6. *p.* 222?) Sand Creek (of the Cimarron) at the margin of a low, swampy place; Sept. — Plant a span high, with the foliage and somewhat the aspect of a Gaura; the leaves minutely strigose-canescent, half an inch long, oblong-lanceolate or linear, entire or obscurely toothed. The wiry stems are very leafy to the top. Calyx-tube slender, three fourths of an inch long, purplish, thrice the length of the ovoid canescent ovary, less than twice the length of the calyx-tube. Petals broadly obovate, entire, two thirds of an inch long, white, with some of each flower conspicuously spotted or blotched with rose-purple. Anthers linear. Divisions of the stigma linear, slender. Capsule sessile, canescent, one fourth of an inch long, and almost as

broad, turgid-ovate, apiculate, with four strongly carinate or almost winged angles, the intermediate ribs scarcely prominent. Seeds numerous in each cell, obovate, with a smooth and thin testa. — This plant accords with the description of Œ. guttulata, *Geyer*, except that the petals are not obcordate. It agrees with the original specimen of the earlier published Œ. canescens; the capsules of which were by an oversight described as *obovate* instead of ovate.

228. Œ. (Pachylophis) eximia (sp. nov.): subcaulescens; foliis elongato-lanceolatis maximis sinuato-pinnatifidis in petiolum attenuatis ad margines costamque dense villosis flores superantibus; ovario sessili fusiformi pluricostato secus costas muricatulo in tubum calycis longissimum patenti-pilosum (laciniis lanceolatis ad carinam villosis 5 – 6-plo longiorem) sensim attenuatis. — Along Santa Fé Creek; June, July. — This is far the largest and most striking species of the section, and apparently one of the handsomest of the genus. My specimen shows a thick and fleshy ascending stem, torn from the root or caudex, a span in length, which bears numerous alternate but approximated leaves, many of them a foot long. These are pinnatifid-sinuate, as in Œ. marginata, *Nutt.*, and with the margins and midrib equally villous. Besides the far greater size, which may be of no consequence, the ovaries and young capsules are strictly sessile in the axils of the leaves, and the older ones are glabrous except towards the apex, where they taper insensibly into the prolonged calyx-tube, showing no exterior indication of the point of separation. They are an inch and a half in length by two lines in diameter, purplish, many-striate, and minutely muricate or tuberculate along the ribs, the older ones incurved. The calyx-tube attains the length of 6 or 7 inches; the segments are fully an inch and a half long, marked with a slightly carinate midnerve, which is villous. The petals are fully the length of the calyx-segments, white, changing to rose-color. Anthers fixed by the middle, almost an inch long. The ripe fruit is unknown.*

229. Œ. (Meriolix, *Raf.*, Calylophis, *Spach.*) serrulata, principally β. Douglasii, *Torr. & Gray, Fl.* 1. *p.* 502. Sandy hill-sides and low prairies, from Las Vegas to the Cimarron; August.

230. Œ. (Salpingia) Fendleri (sp. nov.): minutissime pulverulento-glandulifera, glabra; caulibus e radice lignosa decumbentibus; ramis brevibus adsurgentibus; foliis

* Fine specimens of Œ. montana, *Nutt.*, gathered by Fremont in his second journey, which I have examined in Dr. Torrey's herbarium, perfectly accord with those of Nuttall, and remain distinct from Œ. cæspitosa; but the cylindraceous pods have the sutures slightly crested. The seeds resemble those of Œ. marginata. The tube of the glabrous calyx is only two or three inches long, and twice or thrice the length of the segments. — No. 406 of Geyer's Oregon collection, named Œ. triloba in the published account, is Œ. heterantha, *Nutt.*; which also occurs in Spalding's Oregon collection.

lanceolatis oblongisve sessilibus subintegerrimis; calycis tubo apice infundibulari-inflato ovario prismatico sessili laciniisque triangulari-lanceolatis cuspidatis 3–4-plo longiore; petalis rhombei-obovatis stylo paulo longioribus. — Sunny hill-sides, at Santa Fé, and on the Rio del Norte; also (chiefly a narrower-leaved form) from Rock Creek eastward to the Cimarron River; May to August. — A well-marked species, with numerous stems 4 to 10 inches long, the larger ones procumbent; the whole plant green, but sprinkled with minute glandular or resinous dots. Leaves 1 to 2 inches long, 2 to 6 lines wide, rather obtuse, somewhat scattered. Flower, including the sessile ovary, three inches long, the calyx-tube fully half an inch wide at the throat. Petals about an inch long, "sulphur-color, turning to red in a few days after opening, and in drying." Anthers half an inch long. Stigma dilated, disciform, obscurely 4-lobed. Capsule (immature) an inch long, linear, between prismatic and cylindrical, slightly incurved, of the same diameter throughout, somewhat 4-grooved, glabrous. The flower-buds are spotted with purple, as is often the case with Œ. Missouriensis, to which our plant bears some likeness. — The section *Salpingia* is further confirmed by the discovery of still another species, a dwarf frutescent plant, of which specimens were gathered in Northern Mexico by Dr. Gregg.* In his collection I also find Œ. (Salpingia) lavandulæfolia, *Torr. & Gray*, from the neighbourhood of Buena Vista; from Encantada, also the Œ. Hartwegi (likewise gathered around Monterey by Dr. Edwards and Major Eaton); and from Patos a variety of the same, approaching Œ. lavandulæfolia, with somewhat hoary and toothed leaves. The seeds are oblong and inappendiculate.

231. Gaura epilobioides, *H. B. K. Nov. Gen. & Sp.* 6. *p.* 93? Near fields, Santa Fé; May to Sept. — There are several forms of the plant in the collection, which accord pretty well with the description of G. epilobioides, and, as to the flowers and upper leaves, may well be compared with Epilobium rosmarinifolium. It is the same plant with no. 164 of Coulter's Mexican collection, except that the upper leaves of ours are smoother.

†232. G. villosa, *Torr. in Ann. Lyc. N. Y.* 2. *p.* 200. Along the Cimarron River; August, in fruit. — The fruit is oblong, tapering upwards, about 4 lines long, glabrous,

* Œ. (Salpingia) Greggii (sp. nov.): fruticulosa, ramosissima, erecta, undique minutissime viscido-puberula; foliis parvis (3–6 lin. longis) spathulatis vel oblanceolatis integerrimis sessilibus seu in petiolum pl. m. attenuatis; floribus parvulis; tubo calycis apice breviter obconico filiformi ovario sextuplo laciniisque triangulari-lanceolatis cuspidatis petala rhomboidea subæquantibus quintuplo longiore; capsula sessili oblongo-prismatica. — Hill southeast of Pelayo, in Chihuahua, *Dr. Gregg;* May, 1847. "A very small semi-shrub; flower yellow." The specimens are about 8 inches high, very bushy: the petals turn to rose-color in drying, as in the allied species, and are one third of an inch in length. Capsules scarcely half an inch long.

strongly tetraquetrous, when immature fusiform, but at maturity abruptly contracted into a slender stipe about two lines in length.

†233. G. BIENNIS, *Linn.* Bottom land, Kansas River; August.

†234. G. PARVIFLORA, *Dougl. in Hook. Fl. Bor.-Am.* 1. *p.* 208. Council Grove to Mora River, in low prairies and bottoms.

†235. STENOSIPHON VIRGATUS, *Spach, Mon. Onagr. p.* 64. Prairies, Kansas River: September. Plant 4 to 5 feet high.

†236. LUDWIGIA PALUSTRIS, *Ell. Sk.* 1. *p.* 214. Bluff Creek, near Council Grove: September.

†237. L. ALTERNIFOLIA, *Linn.* Kansas River; August.

238. HIPPURIS VULGARIS, *Linn.* Ponds, Santa Fé; May, June; in flower.

LOASACEÆ.

†239. MENTZELIA OLIGOSPERMA, *Nutt. in Bot. Mag. t.* 1760. (M. aurea, *Nutt. Gen.*) Council Grove, on hills between rocks; August.

240. M. (BARTONIA) ORNATA, *Torr. & Gray, Fl.* 1. *p.* 534. — Between the Rio Colorado (Upper Canadian) and Rock Creek; Aug. Petals, as in the fine specimens gathered by Fremont, &c., 2½ inches long; the stamens nearly 2 inches long and all filiform. — I have never seen this species alive, nor does Mr. Fendler record the color of the flowers; but Mr. Sprague, who observed it on the Missouri, confirms the uniform statement that the flowers are white, at most yellowish-white, and expand at sunset. I have raised the nearly allied M. nuda from seed, the flowers of which are said by Nuttall to be "of the same color" as those of M. ornata; and I observed the *white* corolla uniformly to open an hour or half an hour before sunset, and to remain expanded through the evening. On the other hand, the M. lævicaulis of the interior of Oregon has yellow blossoms, which never expand in the evening, but during bright sunshine, according to Douglas: they are "pale yellow," according to Mr. Breckenridge: "they open during sunny hours, and are of a lurid golden-yellow," according to Mr. Geyer. There is also an evident difference in the foliage, and in the foliose bracts, which are sparing in M. lævicaulis; the latter has but five petals and five dilated filaments; and although, indeed, Dr. Torrey assures me that these are sometimes replaced by five additional petals, still I cannot think that M. lævicaulis should be merged in M. ornata, as has recently been done on the high authority of Sir Wm. Hooker.

241. M. (BARTONIA) NUDA, *Torr. & Gray, l. c.* McNees Creek, and Pawnee Fork of the Arkansas; Aug. to Sept. — This species extends to Texas, on the Cibolo and Pierdenales, whence it has been sent by Lindheimer, along with seeds from which I have

raised the plant. The petals are white, and expand just before sunset, as mentioned above; they vary from an inch and a half to three fourths of an inch in length. In all the specimens I have seen, from various localities, the ovary is more or less foliolose-bracteate at the base, and sometimes as conspicuously so as in M. ornata itself.

242. M. MULTIFLORA, *Nutt. Pl. Gamb. in Jour. Acad. Philad. n. ser.* 1. *p.* 180? under Bartonia. Santa Fé; June, July. Flower seldom open in the day-time. Also along the Arkansas near Bent's Fort; Sept. (I have not seen the latter specimens.) — The specimens are a foot or more in height, with most of the leaves rather deeply pinnatifid, and flowers about one fourth larger than those of an original specimen of Nuttall's Bartonia pumila in Dr. Torrey's herbarium, with which, except in the greater size, they accord tolerably well. The stems become bright white with age, as in other species. The petals apparently straw-color, perhaps white, are one half or one third of an inch in length, obovate or spatulate and rather obtuse, except with age, exceeding the subulate calyx-segments, and longer than the ovary. The outer filaments are conspicuously dilated. I have the same species, apparently, from Coulter's Californian collection, but with rather larger flowers, and more interruptedly pinnatifid leaves. In Dr. Torrey's herbarium I notice specimens, for the most part imperfect, referable either to this plant or to M. pumila itself, gathered on the Upper Platte or Arkansas by Dr. James in Long's expedition, and in the valley of the Rio del Norte, New Mexico, by Lieut. Emory. I can hardly doubt that it is the Bartonia multiflora of Nuttall, although the petals are not quite so large as he describes them. There is a related species in Texas, which I have also flowered in cultivation.*

†243. M. NUDA, var.? with more undivided leaves and smaller blossoms. Low prairie, near the Mora River; August.

* MENTZELIA (BARTONIA) WRIGHTII (sp. nov.): annua, hirsuluto-scabra; caule (bipedali) simplici vel paniculato; foliis oblongo-lanceolatis grosse sinuato-dentatis, infimis in petiolum attenuatis, superioribus basi truncata vel subauriculato-dilatata arcte sessilibus; bracteolis 1–2 linearibus integris ovarium adæquantibus; floribus parvulis ochroleucis; petalis 10 lanceolato-spathulatis lacinias calycis vix superantibus ovario cylindrico brevioribus; filamentis omnibus lineari-subulatis exterioribus paulo dilatatis; placentis 3 polyspermis; seminibus alatis. — On sand-bars in the Colorado, opposite Bastrop, Texas, *Mr. Wright.* — The wild specimens are scarcely two feet high, with a nearly simple upright stem; the leaves only 2 or 3 inches long. Those raised from seed in the Cambridge Botanic Garden attained a greater height, branched copiously, and continued to flower through the summer and until arrested by frost. It bore cauline leaves of from 4 to 6 inches in length and an inch or more in breadth; the upper ones closely sessile by a more or less dilated and truncate base. The leaves are regularly pinnatifid-sinuate into 8 or 10 pairs of coarse and obtuse teeth, rather than lobes, on each side. The flowers open at sunset, or sometimes in a cloudy day; the narrow petals barely one third of an inch in length. Capsule subclavate-cylindrical, an inch long, very rough.

CACTACEÆ. (By *Dr. Engelmann.*)

244. MAMMILLARIA VIVIPARA, *Nutt.* sub Cacto. Common from Bent's Fort to Santa Fé, on rocky hills and elevated plains; flowering in July. — "Heads mostly single, often in pairs, rarely cæspitose from the ramifications of the subterraneous stem"; not proliferous, as some specimens from the Upper Missouri are. — There can be little doubt that this is the true Cactus viviparus of Nuttall, although the flowers do not appear to be entirely central. I have living specimens from Santa Fé, and from the Upper Missouri, and shall be able to decide their identity after having seen them flowering. — I possess, also, a living specimen of Nuttall's Cactus mammillaris (*Gen. p.* 295), and have observed its flower and fruit. It is, as has been long suspected, entirely different from the West Indian Mammillaria simplex, *DC.*, and is nearly related to M. similis, *Engelm. in Pl. Lindh.* I have named it after its discoverer.*

245. M. PAPYRACANTHA (sp. nov.): ovata, prolifera, aculeis omnibus planis chartaceis flexilibus albis, radialibus brevibus 8 centralibus 3 – 4 multo longioribus, 2 – 3 superioribus sursum curvatis, singulo inferiore longiore latiore deorsum flexo; floribus centralibus (albidis); sepalis 12 – 16 ovatis acutis integris; petalis sub-13 lanceolatis acuminatis integris; stigmatibus 5 suberectis exsertis albidis. — In a valley between the lower hills, near Santa Fé, in loose, red sandy, though fertile soil: found only once; flowering in May. — About 2 inches high, and 1½ inch in diameter; the tubercles in about 8 spiral rows; lower ones proliferous; their shape not well distinguishable in the half-rotten specimen before me. Spines silky-white, shining, of the consistency of stiff paper. None of the 8 radiating spines (1½ or 2 lines long) are directed upwards, but all laterally or

* M. NUTTALLII (sp. nov.): simplex (an semper?), globosa, axillis tuberculorum ovato-cylindricorum supra leviter sulcatorum subtomentosis; areolis junioribus albo-tomentosis; aculeis rectis albidis, radialibus 13 – 16 subinæqualibus setaceis, centrali porrecto robustiore; floribus ex axillis tuberculorum hornotinorum centralibus (ex rubello flavicantibus); sepalis petalisque oblongo-lanceolatis; sepalis 10 – 13, brevioribus exterioribus ciliato-fimbriatis obtusiusculis, interioribus apice laceris acutis; petalis 20 – 23 integris breviter abrupte mucronatis; stylo supra stamina (rubella) paulo exserto, stigmatibus circa 5 brevissimis erectis adpressis viridibus; baccis lateralibus subglobosis coccineis. Cactus mammillaris, *Nutt.*, non *Linn.* — On high, dry prairies, about Fort Pierre, on the Upper Missouri; flowering in May. — My specimen is an inch and a half high, and of the same diameter; the tubercles 6 or 7 lines long, in 8 spiral rows, slightly sulcate. Radial spines 4 or 5; the central one 5 to 6 lines long; the young spines at the apex slightly brownish. Flowers an inch long, and, when fully expanded, of the same diameter. Petals about 2 lines wide, acute, abruptly mucronate. Stigmas only from one half to three fourths of a line long, erect. The fruit ripens the following spring, and, as well as the seed, is very similar to that of M. similis, but only half as large, although the pits of the globose black seed are of the same size.

downwards; the 2 or 3 central curved spines are directed upwards, and 6 to 8 or 9 lines long, the middle one shorter or wanting. The lower central spine is the longest (10 to 14 lines) and broadest, being from 1 to 1¼ line wide. Flowers pearly white, 12 to 13 lines long, 12 to 15 lines in diameter. Lower sepals membranaceous; the upper herbaceous in the middle. Petals about two lines wide.

246. Cereus viridiflorus, *Engelm. in Wisliz. Rep. not.* 8, sub Echinocereo. Eastern mountains of Santa Fé, on sunny, rocky declivities; flowering in May and June. — I have seen specimens brought from other parts of New Mexico, of much larger size than than those of Fendler or Wislizenus, some of them 1½ inch in diameter and 3 to 4 inches high, some with stout central spines, others entirely destitute of them.*

* After a careful revision of the characters which distinguish my genus *Echinocereus* (*Wisl. Rep. note* 7) from *Cereus* proper, I think it most natural to unite the two. Echinocereus will then constitute the first section of Cereus, and comprise those of low stature and mostly of cæspitose growth, having diurnal flowers with short tubes (and almost straight embryos with very small cotyledons). It appears to comprise Prince Salm Dyck's (*ined.*) first two sections, viz.: 1. *Lophogoni*, and 2. *Sulcati*; but perhaps not all of the latter. Those known to me as belonging to New Mexico, Chihuahua, and Texas, may be divided into two sections, viz.: —

§ 1. Costati: caule 4 – 10-costato; aculeis radialibus pl. m. porrectis non pectinatis; areolis orbiculatis.

A. *Tuberculis subdistinctis.*

1. C. procumbens (sp. nov. ined.): tuberculis 4 – 5-serialibus; aculeis brevibus tenuibus, 5 – 6 radialibus, 1 centrali. — Matamoras.

B. *Tuberculis in costas confluentibus.*

* *Aculeis plus minusve teretibus.*

2. C. coccineus, *Engelm. in Wisl. Rep. not.* 9. Costis 9 – 11; aculeis radialibus 9 – 10, centrali 1 recto.
3. C. polyacanthus, *Engelm. l. c. not.* 28. Costis 10; aculeis radialibus 10 – 12, centr. 4 rectis.
4. C. Rœmeri (sp. nov. ined.): Costis 7 – 9; aculeis radialibus 8, centrali 1 recto. — Western Texas.
5. C. Fendleri (sp. nov. supra): Costis 9 – 10, aculeis radialibus 7, centrali 1 curvato.

* * *Aculeis compressis, angulatis.*

6. C. enneacanthus, *Engelm. l. c. not.* 46. Costis 10; aculeis radialibus 8, centrali 1 recto.
7. C. triglochidiatus, *Engelm. l. c. not.* 9. Costis 6 – 7; aculeis 3 – 6 subcurvatis.

§ 2. Sulcati: caule sinubus 10 – 24 parum incisis sulcato; areolis pl. m. elongatis; acul. rad. pectinato-connatis.

8. C. dasyacanthus, *Engelm. l. c. not.* 19. Septdec. – octodecim-sulcatus; aculeis radialibus subporrectis, centralibus radiales subæquantibus, pluribus deflexis.
9. C. rufispinus, *Engelm. l. c. not.* 31. Undecim-sulcatus; aculeis rad. adpressis variegatis elongatis, centrali 1 robusto.
10. C. adustus, *Engelm. l. c. not.* 29. Tredecim – 15-sulcatus; aculeis rad. pectinatis albidis adustis, centrali nullo seu 1 robusto. The last form is *β.* radians (Echinocereus radians, *Engelm. l. c. not.* 30).
11. C. viridiflorus, *Engelm. l. c. not.* 8. Tredecim-sulcatus; aculeis rad. pectinatis variegatis, centrali nullo seu 1 robusto.
12. C. pectinatus, *Scheidw.* sub Echinocacto; *Engelm. l. c. not.* 45, sub Echinocereo: Octodecim – 23-sulcatus; aculeis radialibus pectinatis, centralibus 2 – 5 brevissimis.
13. C. cæspitosus, *Engelm. in Pl. Lindh.* Tredecim – 18-sulcatus; aculeis rad. pectinatis, centrali nullo.

247. C. COCCINEUS, *Engelm. l. c.*, sub Echinocereo. Higher mountains about Santa Fé; often in large clusters of 8 or 15 heads; flowering in May. — The areolæ are hardly oval, but almost orbicular, and are distinguished from those of most related species by their large size. — Among a number of plants of this family which Mr. Fendler sent from Santa Fé in a living state, but which unfortunately were all dead when they came to hand, are some specimens which appear to be varieties of this species, viz.: — β. MELANACANTHUS: aculeis radialibus 10 – 12 cinereis, centrali longissimo atrofusco porrecto recto seu leviter deorsum curvato. — γ. CYLINDRICUS: subsimplex, cylindricus; aculeis 8 radialibus, singulo robustiori porrecto.

248. C. TRIGLOCHIDIATUS, *Engelm. l. c.*, sub Echinocereo. Higher mountains about Santa Fé; also in gravelly soil on the lower hills; flowering in May and June. — To the description given in Wislizenus's Report I will add here, that the spines are often somewhat curved; the ridges are sharp, but the grooves between them very wide and shallow; the areolæ widely distant from one another (often over an inch and a quarter), and the expression "*areolis sparsis*," in the character, ought to be changed to *areolis distantibus*.

249. C. FENDLERI (sp. nov.): globoso-ovatus, simplex vel e basi proliferus, cæspitosus; costis 9 – 10 obliquis tuberculatis interruptis; areolis orbiculatis approximatis; aculeis basi bulbosis robustis, radialibus sub-7 compressis subincurvis fuscis demum cinereis (tribus inferioribus longioribus, superioribus brevioribus, summo nullo); aculeo centrali robustiore longiore teretiusculo sursum curvato atro-fusco; floribus campanulatis; tubo pulvillis sub-30 albo-tomentosis stipato, inferioribus aculeos setaceos albos apice adustos 8 – 12 radiales et singulum centralem, superioribus aculeos sub-3 robustiores longiores curvatos albos gerentibus; sepalis interioribus 12 – 15 lineari-lanceolatis acutis; petalis oblongo-linearibus, acutis vel obtusis 16 – 24; stigmatibus 12 – 14 viridibus stamina numerosissima vix superantibus. — β. PAUPERCULUS: aculeis robustis abbreviatis, radialibus 5 – 7, centrali subnullo. — Santa Fé, on elevated sandy plains; flowering in June. — The specimens before me are 2½ inches high, and at the base of the same diameter: the areolæ from 4 to 6 lines distant; the lower radial spines 7 to 10, the upper from 3 or 4 to 6 lines long; central spine somewhat erect, curved upwards, 10 to 15 lines long. In var. β. the spines are all from 3 to 6 lines long. The upper spine is wanting in all my specimens, and the opposite lowest one is longer than any except the central spine. Flowers from 2½ to 3¼ inches long and wide, violet-purple. The spines on the lower part of the tube are from 2½ to 3, and on the upper from 3 to 5 lines long. Petals variable in shape.

250. OPUNTIA PHÆACANTHA (sp. nov.): diffusa; articulis obovatis seu orbiculato-

obovatis compressis; areolis orbiculatis fusco-setosis margine inferiore aculeos robustos 1 – 5 rectos compressos inæquales fuscos apice pallidiores plerumque deflexos gerentibus rariusve nudis; ovario obconico areolis sub-30 tomento pallide fusco instructis, superioribus albo-setosis; sepalis interioribus sub-20 late obovatis retusis seu emarginatis; petalis 10 – 13 obovatis retusis seu emarginatis; stigmatibus 5 – 7 suberectis stamina vix superantibus; bacca obovato-pyriformi nuda. — On rocky hills about Santa Fé, and on the Rio Grande, very common; flowering in May and June. This appears to be the most northern form of the Opuntiæ with yellow or brown and flattened spines, which belong to the section of *O. Tuna*. Another species, with larger joints and larger fruit, occurs in Texas. — Some specimens before me are prostrate, with ascending branches; the joints 5 or 5½ inches long, and 3½ or 4 wide; areolæ an inch distant from each other, most of them bearing stout spines; the lower sometimes only one, the upper from two to five, but mostly three or four: one or two are directed upwards, the other and stouter ones more or less downward. Larger spines 1½ to 2 inches long, dark brown with lighter tips; the smaller from half an inch to one inch long, whitish. — Another specimen has larger, more orbiculate joints, from six to eight inches long, and five or six wide; the spines fewer, all directed downwards, or on many areolæ none at all. The flowers which have been distributed under this number are two or two and a half inches in diameter: ovary about one inch long: sepals yellow with red: petals yellow: stamens red or yellow: stigmas apparently green. The fruit which Mr. Fendler says belongs to this species is about half an inch long, red, smooth, apparently juicy when fresh; the seeds often three lines in diameter, margined like those of O. vulgaris. — Several other Opuntiæ with compressed joints, some of them with fleshy, others with dry and spiny fruit, some of them very spiny, and others almost destitute of spines, have been collected by Mr. Fendler about Santa Fé; but for want of more complete materials, a description is not here attempted.

✓ 251. O. CLAVATA, *Engelm. in Wisliz. Rep. not.* 12. Plains around Santa Fé; never found on the mountains; flowering in June. — I add to the description already published, that the areolæ are very large and closely approximate. From nine to eleven smaller and narrower spines are directed upwards or radiating; about six of them are turned downward, and are larger and longer; the former are from two to four, or even six or eight, lines long; the latter are from six to fourteen lines long. The joints form a large and spreading, level-topped mass, which attains the diameter of several feet.

✓ 252. O. ARBORESCENS, *Engelm. l. c. not.* 5. Hills and elevated plains, from Bent's Fort on the Arkansas to Santa Fe; flowering in June. — About five feet high, sometimes

as much as five inches in diameter below; the older stems and branches terete; the younger joints strongly tuberculated. Spines often an inch long, generally from 15 to 25 in each fascicle.

GROSSULARIACEÆ.

253. RIBES IRRIGUUM, *Dougl. in Hort. Trans.* 7. *p.* 516. Margin of Santa Fé Creek; May. — The specimens are in flower only. The pedicels are short, as in R. hirtellum, *Michx.* (*Torr. & Gray, Fl.* 1. *p.* 546), which the plant much resembles; but the leaves are rounder and more downy, the campanulate calyx is yellowish-green, with no purple tinge, and the spines are triple. The stamens are somewhat longer than the petals, but shorter than the oblong calyx-lobes. These are not mentioned in the published character of R. irriguum, *Dougl.* But I am confident that this is the species in question, as I have the same from the valley of the Kooskooskee, where it appears to abound. According to Mr. Spalding, who sends it, it grows by the water-side, and yields "a most delicious gooseberry or currant, tasting like a plum." The same is in Geyer's collection, (No. 330), in flower, under the name of R. triflorum. The fruit scarcely exceeds a large currant in size, and is perfectly smooth. — From Mr. Spalding I also have characteristic specimens of R. divaricatum, *Dougl.*, which, he remarks, is often twelve feet high, and which is likewise said by Geyer to form "a robust shrub or small tree, 8 to 15 feet high, very thorny; stems 2 to 4 inches in diameter."

254. R. LEPTANTHUM (sp. nov.): glabrum, esetosum; spinis subaxillaribus solitariis validis rarius geminis ternisve; foliis parvis (4–6 lin. latis) crebris 5-fidis, lobis incisis; pedunculis brevibus deflexis 1–2-floris; pedicellis subnullis; bracteis rotundatis ovario brevioribus; calyce tubuloso gracili extus piloso albido, lobis subspathulatis tubum æquantibus staminibus petalisque integerrimis subduplo longioribus; stylo glabro indiviso; stigmatibus binis; baccis inermibus glabris. — Rocky banks of the Rio del Norte, and ravines near Santa Fé; May. — Shrub 3 to 4 feet high. Flower nearly half an inch in length. — Very distinct from any species in the *Flora of North America*; apparently resembling the R. microphyllum, *H. B. K.*, of Mexico, which, however, is said to have very short peduncles, red flowers, a campanulate calyx, retuse petals, and a 2-cleft style.

255. R. CEREUM, *Dougl. l. c.; Torr. & Gray! Fl.* 1. *p.* 551. (R. pumilum & R. reniforme, *Nutt.! Mss.*) Shaded banks of Santa Fé Creek; May, in flower. Shrub 3 to 4 feet high.

†256. R. sp.; leaves only, of a glutinous species, perhaps merely a form of R. cereum. Rocky hill-sides, near Santa Fé, and on the Mora River.

257. R. AUREUM, *Pursh, Fl.* 1. *p.* 164. River banks and bottoms, from Mora River to Rock Creek; August. In fruit only.

CUCURBITACEÆ.

†258. ECHINOCYSTIS LOBATA, *Torr. & Gray, Fl.* 1. *p.* 542. Hickory Point, about eighty miles west of Independence.

259. DISCANTHERA DISSECTA, *Torr. & Gray, Fl.* 1. *p.* 697; var. foliis pedato-partitis (haud sectis). Rock Creek bottom, New Mexico; August.

260. CUCUMIS? PERENNIS, *James in Long's Exped.* 2. *p.* 345; *Torr. & Gray, Fl.* 1. *p.* 543. Low places, Santa Fé; June. — I have this in cultivation, from Texan seeds, and hope to notice it more particularly in the forthcoming enumeration of Lindheimer's collection, part 2.

†261. CUCURBITA PEPO, *Linn.* Fields, around Santa Fé.

CRASSULACEÆ.

†262. SEDUM RHODIOLA, *DC.?* Rocks, in the mountains near Santa Fé Creek. Scarcely in flower. The plant is only 3 or 4 inches high, and the leaves are entire, as in the specimens mentioned by Torrey, in *Ann. Lyc. New York*, 2. *p.* 206.

†263. PENTHORUM SEDOIDES, *Linn.* Near Council Grove.

SAXIFRAGACEÆ.

264. HEUCHERA PARVIFOLIA, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 581. Rocks, on the northern face of mountains, Santa Fé; June, July; in flower.*

265. SAXIFRAGA BRONCHIALIS, *Linn.; Torr. & Gray, Fl.* 1. *p.* 564. Steep and shaded rocky banks, Santa Fé Creek; May, June.

266. PHILADELPHUS MICROPHYLLUS (sp. nov.): ramis gracilibus erectis; foliis parvis (6 – 9 lin. longis) ovato-lanceolatis oblongisve integerrimis obtusiusculis obsolete triplinerviis supra nitidis subtus pallidis minute pilosis basi in petiolum brevissimum angustatis; floribus terminalibus solitariis ternisve; calyce quadrifido extus glabro, laciniis ovato-lanceolatis intus tomentulosis; stylis ad apicem usque connatis staminibus brevioribus; stigmatibus 4 oblongis; capsulis subglobosis. — Santa Fé Creek, on sunny and

* Heuchera hispida, *Pursh*, the rediscovery of which in the mountains of Virginia (in Giles county) I have recorded in *Silliman's Journal, second series*, 1. *p.* 81, and which I have retained in cultivation in the Cambridge Botanic Garden, is also found in Hancock county, Illinois, by Dr. Mead, who has distributed it under the name of H. Richardsonii, *R. Br.*; from which, indeed, except that it is a larger and more hairy plant, it does not appear to differ.

steep sides of the mountains, between rocks, eleven miles above Santa Fé; June, July. — A very handsome species, well distinguished by its remarkably small leaves. The specimens bear a profusion of flowers, which are for the most part solitary at the apex of the branchlets, and are large in proportion to the foliage, the petals being nearly equal in size to the leaves themselves. Their margins are somewhat erose.

267. JAMESIA AMERICANA, *Torr. & Gray! Fl.* 1. *p.* 593. Banks of Santa Fé Creek, near the water, where the stream is walled in on both sides by high rocks; June. — The genus was founded upon an extremely imperfect specimen, gathered by Dr. James in Long's expedition to the Rocky Mountains. The fine specimens brought by Fendler now afford the opportunity of completing, and correcting in some points, the generic character; which is accordingly appended.*

UMBELLIFERÆ.

†268. SANICULA MARILANDICA, *Linn.* Near Council Grove; September.

†269. CICUTA MACULATA, *Linn.* With the last.

270. C. MACULATA, *Linn.*, var. foliolis angustioribus. Banks of Mora River; Aug.

†271. BERULA ANGUSTIFOLIA, *Koch, Fl. Germ. p.* 287. (Sium angustifolium, *Linn.*)

* JAMESIA, *Torr. & Gray, Fl. N. Am.* 1. *p.* 593.

Flores hermaphroditi. Calyx persistens, quinquefidus, tubo brevissimo turbinato imo ovario adnato; laciniis triangulari-ovatis mucronatis, sæpiusve apice retusis aut bifidis et bimucronatis, æstivatione valvatis? Petala 5, perigyna, obovata, concava, sessilia, æstivatione convoluto-imbricata, decidua. Stamina 10, cum petalis inserta, decidua, 5 petalis antepositis eadem subæquantibus, 5 alternis brevioribus: filamenta complanato-subulata: antheræ didymæ, basifixæ, introrsæ; loculis ovalibus longitudinaliter dehiscentibus. Ovarium conoideum, ima basi calycis adnatum, uniloculare; placentis 3 (rarius 4–5) dilatatis, ad suturas introflexas parietalibus, multiovulatis: styli totidem, stamina æquantes, basi tantum connati, apice subclavati stigmate obtuso subextrorsum desinentes. Ovula horizontalia, multiseriata, anatropa. Capsula conoidea calyce inclusa, semi-trilocularis, apice inter stylos persistentes divergentes dehiscens. Semina numerosissima, horizontalia, ovalia; testa nitida, nucleo conformi, striato-reticulata. Embryo in axi albuminis carnosi rectus, ejusdem fere longitudine; cotyledonibus brevibus; radicula cylindrica hilo proxima. — Frutex ramosus, cortice fusco; foliis oppositis, exstipulatis, petiolatis, ovatis vel oblongis, penninerviis, grosse serratis, membranaceis, deciduis, supra pubescentibus viridibus, subtus cum ramulis calycibusque canescenti-pilosis; floribus cymosis, majusculis, albis; petalis intus puberulis.

The foliage and flowers are somewhat like those of Pyrus Aria in aspect. — To the vicinity of this genus I should have referred the curious Pterostemon Mexicanus, *Schauer, in Linnæa*, 20. *p.* 736, which is also in Coulter's Mexican collection, no. 85, from Zimapan (but without fruit), except that Schauer describes the seeds as destitute of albumen, and notices minute stipules. He refers the genus to Pomaceæ, and considers it as an intermediate link with Myrtaceæ. I notice that the petals are convolute in æstivation: but so they are, likewise, in Gillenia.

Santa Fé Creek; August. Although destitute of fruit, the specimen well agrees with the European plant. Perhaps it is also the Sium pusillum of Nuttall. I have the same plant, in flower only, from Michigan.

272. Archemora Fendleri (sp. nov.): radice fasciculato-tuberosa; caule simplici; foliis pinnatis 5–7-foliolatis; petiolis basi spathaceis; foliolis oblongo-ovatis obtusis vel fol. supremorum lanceolatis inciso-serratis utrinque viridibus; involucellis nullis; fructibus parvulis angusto-alatis. — Margins of Santa Fé Creek, in fertile soil; June, July. — This is clearly a congener of Archemora rigida, although it wants the involucels. The root consists of three or four oblong, fasciculated, and pendulous tubers about an inch long. Stem slender, one to two feet high. Cauline leaves two or three. Leaflets three fourths of an inch to an inch and a half long; those of the radical and lower cauline leaves ovate or oblong, obtuse; all incisely serrate throughout; not barely 2–3-toothed, as in A. rigida. Umbel small. Fruit hardly two lines in length, oval; the wing-like margins narrower than the disk. Vittæ of the commissure four, of which two are shorter, as is often the case in A. rigida.

273. Heracleum lanatum, *Michx.* With the preceding; June, July, in flower.

274. Cymopterus Fendleri (sp. nov.): pumilus, subcaulescens; foliis viridibus 2–3-pinnato-partitis ambitu oblongis vel ovato-lanceolatis pedunculos excedentibus, pinnis segmentisque 5–7 oblongis obtusis incisis superioribus confluentibus, rachi latiuscula; umbella glomerata pauciradiata; involucro obsoleto; involucellis unilateralibus herbaceis 3–5-partitis flores luteos æquantibus, laciniis oblongis; fructibus plerumque 7-alatis, alis membranaceis planis. — Gravelly hills, Santa Fé; April to May. — Stem one to two inches long, rising from a thickened perpendicular root or caudex. Petioles and peduncles about the same length, minutely pulverulent-glandular. Leaves thickish, not glaucous, the lamina of the larger two inches long; the pinnæ and segments little crowded. Flowers crowded in the monœcious umbellets, on very short pedicels; the central ones staminate; the marginal pistillate. The fruit is not mature, but nearly resembles that of no. 275: one of the mericarps bears two (usually unequal) wings on the back; the other only one. It is a well-marked species.

275. C. montanus, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 624. With the preceding, in one locality only; April, May. — The specimens accord very well with an authentic one from Nuttall (in *herb. Torr.*), except that the foliage is more glaucous, and the segments of the leaves more crowded, in these respects more nearly resembling C. glaucus. But the species is well characterized by the conspicuous scarious and silvery white, somewhat cyathiform involucre and involucels, marked with greenish ribs, each about 5-parted, the involucels into obovate and obtuse entire divisions, the involucre into similar or

often 2–3-cleft divisions. The marginal flowers are pistillate only, and fertile; the central are staminate. My specimen exhibits scarcely full-grown fruit, with one of the mericarps 4-winged, the other quite uniformly 3-winged (but Nuttall's specimen shows some 10-winged fruits), and the wings are broad and membranaceous, often unequal. Frequently the mericarps appear to be more or less dislocated, and one is often imperfect. Although the commissure is nearly plane, the albumen shows a manifest tendency to become involute; and in a specimen gathered by Fremont in his second expedition (in *herb. Torr.*), with perfectly mature fruit, the section of the albumen is strictly semilunar, as is also the case in a smaller degree in C. campestris and even in C. glomeratus. The genus might, therefore, as well be referred to the Campylospermæ, if there were a tribe to receive it: but as the wings belong to the primary juga, it cannot be placed in the Elæoselineæ. — In Fremont's specimen the carpophore is seen to be free and 2-parted, just as in C. campestris; and the fleshy root is fully six inches long and much thickened downwards.

276. Thaspium? montanum (sp. nov.): glaberrimum; caule erecto gracili e radice fusiformi crassa; foliis biternatisectis, foliolis cuneiformibus trifidis, lobis oblongis lanceolatisve nunc linearibus integris vel majoribus incisis; petiolis longe spathaceo-dilatatis; involucro nullo; involucello e foliolis circ. 9 setaceis inæqualibus pedicellos æquantibus. — Sunny declivities, at the foot of mountains, along Santa Fé Creek; April and July. — There are two forms in the collection; one, probably the vernal state, is only a span high, with the leaves cut into linear or lanceolate divisions; the other, probably gathered in July, is a foot or two in height and with coarser foliage. There is apparently no other distinction. The base of the stem is clothed with brown vestiges of radical sheaths. The flowers are bright yellow. One specimen exhibits half-grown fruit, which agrees very well with Thaspium, except that the dorsal wings are rudimentary: the intervals show single or double vittæ.

†277. An Umbellifera Cœlosperma, in fruit only, not determined. Near the Mora River, in an elevated, rocky region; August.

278. Coriandrum sativum, *Linn.* Naturalized around Santa Fé. It occurs in all the collections made in Northern Mexico.

CORNACEÆ.

†279. Cornus stricta, *Lam.* Between Independence and Council Grove, in bottom land.

280. C. stolonifera, *Michx.; Torr. & Gray, Fl.* 1. *p.* 650. Shady banks of Santa Fé Creek, close to the water; May, June, in flower.

LORANTHACEÆ.

281. PHORADENDRON JUNIPERINUM (*Engelm. Mss.*): "glabrum, caule articulato divaricatim ramosissimo ramisque teretibus; ramulis compressis; foliis squamæformibus connatis truncatis vix cuspidatis pelviformibus breve ciliatis; spicis fœmineis lateralibus oppositis abbreviatis bifloris; floribus bractea inferiore majore et duabus lateralibus in cupulam connatis ciliatis fultis globosis 3- (rarissime 4-) lobis." *Engelm.* — "Parasitic on the two kinds of Shrub Cedar (Juniperus) which grow on the hills and elevated plains about Santa Fé, and on no other tree; sometimes forming clusters of more than a foot in diameter and three fourths of a foot in height. Wherever they are found, they abound on many neighbouring trees. The berry is globose, glossy, of a light champagne color, with a tinge of red when dried." *Fendl.* — The specimens are all fertile and in fruit; so that it is not known whether the plant has the anthers of the genus, but of this there is little doubt, as the species is apparently too closely allied to the Phoradendron Californicum, *Nutt.*, which is "parasitic on a Strombocarpus" (Prosopis).*

* The genus *Phoradendron* has recently been briefly indicated by Nuttall (in *Jour. Acad. Philad. n. ser.* 1. *p.* 185), but was unknown to Dr. Engelmann when he communicated to me the subjoined characters of *Viscum*, *Arceuthobium*, and *Spiciviscum*, Engelm., and of some species of the latter, the name of which I have necessarily changed to Phoradendron.

"1. VISCUM, *Linn.* Flores diœci *campanulati. Fl. masc.* Perianthium 4 fidum; *antheræ lobis totis adnatæ multicellulosæ, poris plurimis dehiscentes. Fl. fœm.* Calyx tubo cum ovario connato, margine integro, limbo obsoleto. Corolla 4-petala, summo calyci inserta. Ovarium inferum, uniloculare; ovulo unico pendulo: stigma sessile, obtusum, subbilobum. Bacca pulposa, corolla persistente coronata, monosperma. — Frutices gerontogei, foliosi, parasitici; foliis oppositis; floribus masculis glomeratis terminalibus; fœmineis in spicas articulatas breves terminales congestis, in quævis bracteæ axilla singulis.

"I have examined only Viscum album, and based the characters on that species.

"2. SPICIVISCUM (nov. gen.) [lege PHORADENDRON]. Flores diœci *globosi. Fl. masc.* Perianthium 3- (raro 2- s. 4-) lobum; *antheræ lobis imis adnatæ, transverse biloculares, poris s. rimulis verticalibus duabus dehiscentes. Fl. fœm.* Perianthium 3- (raro 2- s. 4-) lobum. Ovarium inferum, uniloculare; ovulo unico pendulo: stigma sessile obtusum. Bacca pulposa, perianthio persistente coronata, monosperma. — Frutices Americani foliosi s. aphylli, parasitici; floribus in spicas axillares longiores interruptas articulatas s. abbreviatas dispositis, sæpe pluribus supra quævis bracteæ axillam rhachidi immersis; bracteis abbreviatis connatis vaginulam pelviformem formantibus.

"3. ARCEUTHOBIUM, *M. Bieb.* Flores diœci, *ovati, compressi. Fl. masc.* Perianthium tripartitum, *antheræ lobis mediis adnatæ, globosæ, uniloculares, rimula transversa dehiscentes. Fl. fœm.* Perianthium brevissime stipitatum, bidentatum. Ovarium inferum, uniloculare; ovulo unico pendulo: stigma sessile conicum. Bacca (pulposa ?) corolla persistente coronata, monosperma. — Frutices gerontogei et Americani, aphylli, articulati; foliis ad squamas connatas pelviformes reductis; floribus axillaribus terminalibusque, masculis 1 – 3, fœmineis singulis.

† 282. Arceuthobium Oxycedri, *M. Bieb.?* (A. gracile, *Engelm, Mss.*) A slender form, or perhaps an undescribed species, as Dr. Engelmann considers it; but the fruit is unknown. Mountain-sides, around Santa Fé, parasitic on Pinus edulis, *Engelm.*

283. A. Oxycedri, *M. Bieb.?* (A. robustum, *Engelm. Mss.*) Ravines, on the lower part of the mountains around Santa Fé, parasitic on Pinus brachyptera, *Engelm.*; March, April, in young fruit. — The same as Oregon, Californian, and Mexican speci-

" PHORADENDRON, *Nutt.*

* *Aphylla.*

1. [P. Californicum, *Nutt. l. c.* Mountains of California. Perhaps same as the next.]

2. " P. juniperinum, *Engelm. supra.* Santa Fé.

* * *Foliosa.*

3. P. flavescens (*Nutt. l. c.*): " ramis teretibus; foliis obovatis in petiolum attenuatis 3-nerviis, junioribus puberulis; spicis folio brevioribus; bracteis truncatis ciliatis; floribus in quovis articulo 6 – 10 depresso-globosis annulato-carinatis parce pubescentibus 3- (rarissime 2-) lobis. (V. flavescens, *Pursh.*) — On Platanus and Ulmus, in the woods of the lower Ohio and from there south; on Populus, along the Rio Grande below Santa Fé (*Dr. Wislizenus*). A well-known species; flowers half a line in diameter.

4. " P. orbiculatum (sp. nov.): ramis teretibus; foliis orbiculatis s. ovato-orbiculatis breviter et abrupte petiolatis indistincte trinerviis pubescentibus demum glabratis; spicis folio brevioribus puberulis, etc., ut supra. — On different species of Quercus; on Q. nigra, sterile hills of Arkansas (*Engelm.*); on several Oaks, San Felipe, Texas (*Lindheimer*). — Leaves on the older branches exactly orbicular, 6 to 10 lines in diameter; young leaves somewhat longer than wide: petioles a line and a half long: flowers half a line in diameter.

5. " P. tomentosum: tomentosum; ramis teretibus; foliis obovatis s. oblanceolatis obtusis in petiolum brevem breve attenuatis, senioribus subtus obscure trinerviis; spicis masculis folium longe superantibus; bracteis truncatis, articulis elongatis multi- (15 – 25-) floris; spicis fœmineis folio subbrevioribus oppositis s. verticillatis ad apicem caulis paniculatim congestis, articulis brevioribus sub 8-floris; floribus immersis depresso-globosis annulato-carinatis puberulis 3- (rarissime 4-) lobis. (V. tomentosum, *DC. Prodr.* 4. *p.* 670.) — On Algarobia and one or two other Mimoseæ, near Rinconada, Northern Mexico, *Dr. Gregg.* — No doubt the same as De Candolle's plant, which was collected in Northern Mexico by Berlandier, also on Mimoseæ. Leaves an inch or one and a quarter long, and half as wide. Sterile spikes one and a half to two and a half inches long: female spikes only about an inch long: flowers very similar to those of both the foregoing species, and of the same size or rather smaller. Fruiting spikes slightly elongated, an inch to an inch and a half long: berries one line and three fourths to two lines in diameter.

6. " P. lanceolatum (sp. nov.): glaberrimum; ramis teretibus; foliis lanceolatis elongatis subfalcatis obtusiusculis in petiolum brevissimum sensim attenuatis 3 – 5-nerviis; spicis masculis folio brevioribus; bracteis triangularibus connatis; articulis 8 – 18-floris; floribus immersis globosis 3- (rarius 4-) lobis. — On 'Live-Oak,' Rinconada, *Dr. Gregg.* — Leaves 3 inches long, half an inch wide: sterile spikes an inch and a half to two inches long. Flowers less than a line in diameter; distinguished from those of the foregoing species by being destitute of the horizontal edge, and entirely glabrous, as is the whole plant. Anthers very distinct, similar to the common form of two-celled anthers, opening longitudinally, while in the other species they open by two pores. — Apparently near V. Schiedeanum, *DC.*, but distinguished by the terete branches." *Engelm. Mss.*

mens, which Mr. Bentham and others state that they cannot distinguish from the A. Oxycedri of the Old World.

CAPRIFOLIACEÆ.

†284. Symphoricarpus vulgaris, *Michx.* Pawnee Fork bottom. — Var. foliis incisis v. pinnatifidis. Santa Fé Creek.

†285. S. occidentalis, *R. Br.; Torr. & Gray, Fl. 2. p. 4.* Poñi Creek, between Bent's Fort and Santa Fé.

286. Sambucus pubens, *Michx.* Margin of Santa Fé Creek; June, in flower.

RUBIACEÆ.

287. Galium boreale, *Linn.* Shady banks of Santa Fé Creek; June, July.

288. G. Fendleri (sp. nov.): perenne; caulibus e basi sublignosa adsurgentibus gracilibus pube minuta scabrida subcinereis; foliis quaternis linearibus (¼ unc. longis) acutis uninerviis undique hispidulo-scabridis subcinereis internodio multum brevioribus; pedunculis axillaribus et terminalibus brevibus 3–7-floris; floribus pallide luteis breviter pedicellatis; ovario fere glabro (fructu ignoto). Var. β. superne subglabra; foliis paulo longioribus. — Sunny side of high mountains, valley of Santa Fé Creek; July, in flower only. — Plant 9 to 12 inches high; the leaves and stems more or less cinereous with a minute and close scabrous pubescence. This, however, is nearly wanting, except on the lower leaves and the main stems, in the var. β., which is a more developed state, and a good deal resembles G. trifidum. The ovary shows a few minute bristly points, so that perhaps the fruit is not smooth. The flowers are about as large as in G. trifidum and are said by Fendler to be "pale yellow."

289. G. asperrimum (sp. nov.): annuum? caulibus diffusis angulis retrorsum aculeolatis; foliis omnibus senis lanceolatis basi attenuatis vel inferioribus obovato-lanceolatis apice setigero-acuminatis glabris nitidis marginibus carinaque subtus retrorsum aculeolatis asperrimis, ramealibus parvis pedunculo multum brevioribus; cymis paniculatis plurifloris trichotomis; petalis albis majusculis; ovario pilis brevibus uncinatis dense tecto (fructu ignoto). — Wet places, near irrigating ditches, Santa Fe; June. — Plant in aspect between G. Aparine and G. asprellum. The specimens, not yet in fruit, are apparently erect, and only 7 to 14 inches high. The lower leaves are three fourths of an inch long, but the upper and those of the flowering branches much reduced in size, so that the flowers, which are larger than in G. spurium (corolla two lines in diameter; petals 3-nerved, ovate, acuminate), form a somewhat naked pyramidal panicle, occupying the upper part of the stem. The capillary peduncles are one half to three fourths, the pedi-

cels about one fourth, of an inch long. I am not sure that the root is annual. The character of G. Mexicanum, *H. B. K.*, agrees pretty well with this plant, except that the leaves of that species are in eights.

†290. CEPHALANTHUS OCCIDENTALIS, *Linn.* Council Grove, &c.

291. HEDYOTIS (HOUSTONIA) RUBRA. (Houstonia rubra, *Cav. Ic. 5. t. 474*; *Benth.! Pl. Hartw. p.* 15.) Foot of dry, gravelly hills, seven miles southwest of Santa Fe; May. Flower bluish-red. — This plant is diœcio-dimorphous in the same manner as H. cærulea (*cf. Torr. & Gray, Fl. 2. p.* 38). Lindheimer and Wright have also gathered the plant in Texas.

†292. H. (AMPHIOTIS) STENOPHYLLA, *Torr. & Gray, Fl. 2. p.* 41. Prairie, between McNees Creek and Cold Spring, of the Cimarron; August.

VALERIANACEÆ.

293. VALERIANA EDULIS, *Nutt. in Torr. & Gray, Fl.* 1. *p.* 48. Elevated, rocky region from Las Vegas to the Mora River; Aug. — The root of this plant furnishes the principal article of food of the "Root-diggers" of the country around the Great Salt Lake, &c. Dr. Torrey assures me that the V. ciliata, *Torr. & Gray*, of Canada and the Western States, is the same species; and these specimens, which show the ciliate leaves, confirm that view. The plant is subdiœcious, as was long since remarked by Mr. Sullivant.

294. V. SYLVATICA, *Richards. Appx. Frankl. Journ. ed. 2. p.* 2; *Torr. & Gray, Fl. 2. p.* 47. Rocky and shady declivities, along Santa Fé Creek; April and May, in flower; June, in fruit.

COMPOSITÆ.

†295. VERNONIA NOVEBORACENSIS, *Willd.*, var. Ford of the Arkansas; September.

296. PECTIS (PECTIDOPSIS, *DC.*) ANGUSTIFOLIA, *Torr.! in Ann. Lyc. N. Y. 2. p.* 62. Between Santa Fé and Pecos; Aug. (535.*) — Fine specimens of this rare plant were gathered on the Upper Arkansas by Fremont, in his second expedition, and by Lieut. Abert. It has a true *pappus coroniformis*.†

* From this onward, the numbers inclosed in parentheses, and usually placed after the habitat, are those under which the specimens have been distributed.

† The pappus in the *Eupectideæ* presents such numerous variations and gradations, that it will be necessary either to introduce several additional genera, undistinguishable in habit, or to extend the character of Pectis, and restore to it Pectidopsis, Pectidium, and perhaps Lorentea also. Considering the latter to be the proper mode, I have two additional subgenera to propose, with some new species, viz.: —

†297. LIATRIS SQUARROSA, *Willd.* Near Fort Leavenworth, &c.; August. (332.)

†298. L. SQUARROSA, δ. INTERMEDIA, *Torr. & Gray, Fl. 2. p. 68.* Prairies on the Arkansas below Turkey Creek; September. (331.)

1. PECTIS § HETEROPECTIS. Pappus coroniformis et 1–4-aristatus, vel saltem fl. disci muticus; aristis serrulato-scabris.

P. FASTIGIATA (sp. nov.): erecta, glabra; caule fastigiato-ramosissimo; foliis marginibus revolutis linearifiliformibus mucronatis grosse glandulosis basi setis utrinque 2–3 instructis; corymbis terminalibus confertis; pedicellis setaceo-bracteatis capitula subæquantibus; involucri 20-flori squamis 8 linearibus subcomplicatis apice obtusis uniglandulosis; ligulis 6–8 oblongis conspicuis; corollis disci subregularibus; acheniis parce hispidulis; pappo coroniformi et in fl. radii discique exteriorum 1–2-aristatis, aristis corolla dimidio brevioribus basi vix dilatatis. — Dry hills near Austin, Texas, *Mr. Charles Wright;* flowering in September. — A pretty annual, from 4 to 6 inches high; the fastigiate branches terminated by dense corymbs; the flowers bright golden-yellow; rays two lines long. Leaves an inch or more in length, half a line wide. The plant bears some resemblance to P. tenella, *DC.*, and probably also to P. uniaristata, which must likewise belong to this section.

P. FILIPES (*Harv. & Gray in Pl. Coult. ined.*): subglabra, erecta; caule ramosissimo diffuso; foliis angusto-linearibus obtusis muticis marginibus revolutis scabris pauciglandulosis basi parce piliferis; pedunculis capillaribus ebracteatis folia superantibus; involucri 10-flori squamis 5 eglandulosis basi complicato-carinatis apice dilatato-spathulatis obtusis; ligulis 5 obovatis; corollis disci manifeste bilabiatis; acheniis parce puberulis; pappo radii biaristato, disci coroniformi rariusve uniaristato, aristis e basi subulata setiformibus sursum scabris divergentibus. — California, *Coulter* (no. 329). — Plant of the size and aspect of P. linifolia.

P. COULTERI (*Harv. & Gray, l. c.*): puberula, diffuse ramosa; foliis angusto-linearibus obtusis crebre et grosse glandulosis marginibus revolutis basi setis brevibus dentibusve piliferis auctis; pedunculis folia subsuperantibus capitulum 20-florum adæquantibus ebracteatis; squamis involucri 5 oblongis carinatis; corollis disci valde bilabiatis; acheniis puberulis; pappo radii 3–4-, disci 2–3-aristato; aristis rigidis retrorsum serrulato-hispidis. — California, *Coulter* (no. 330). — Leaves half an inch long. Heads solitary, half an inch long.

P. MULTISETA, *Benth.*, which also has retrorsely barbed awns, equally belongs to this section, which is remarkable for the tendency to have a more reduced pappus in the disk than in the ray.

2. PECTIS § PECTOTHRIX. Pappus e setis aristisve gracilibus basi vix dilatatis 6–20 (raro paucioribus) serrulato-scabris vel barbellatis constans, conformis, aut fl. radii brevis auriculæformis.

P. PAPPOSA (*Harv. & Gray, l. c.*): glabra; caule ramoso diffuso; foliis angusto-linearibus gracilibus sparsim grosse-glandulosis basi utrinque 3–4-setiferis; pedunculis 1–3-bracteatis folia subsuperantibus; capitulis solitariis corymbosisve; involucri circ. 20-flori squamis angusto-linearibus complicatis glandulis parce punctatis obtusis; ligulis 6–8; corollis disci bilabiatis; acheniis uncinato-pubescentibus; pappo fl. radii dimidiato-auriculæformi, disci e setis barbellatis 15–20 valde inæquælongis. — California, *Coulter* (no. 331). — Bristles of the disk-pappus slender, all alike, except in size; the longest scarcely equalling the corolla, the shortest one fourth of that length, all denticulate-barbellate, the barbellæ spreading or upturned: pappus of the ray composed of three more or less united, very short and obtuse scales.

P. DIFFUSA, *Hook. & Arn.* (P. arenaria, *Benth.*), and P. ELONGATA, *Kunth*, belong to this section.

P. TENELLA, *DC.* (of which copious specimens were gathered by Dr. Gregg on the Rio Grande east of Mier) connects this group with Pectis proper; the bristles of the pappus being somewhat enlarged toward the base. Their number varies from three to five in the ray, and from three to six in the disk.

299. L. PUNCTATA, *Hook. Fl. Bor.-Am.* 1. *p.* 306. *t.* 55. From Cottonwood Creek, of the Arkansas, to San Miguel, New Mexico. (328.) "One specimen had white flowers."

† 300. L. SPICATA, *Willd.* Low prairie, Middle Spring, Cimarron; August. (299.)

† 301. L. PYCNOSTACHYA, *Michx.* Dry prairies, &c., south of Fort Leavenworth; August. (330.)

302. L. SCARIOSA, *Willd.* Council Grove to Fort Leavenworth; August. (333.) Some specimens exhibit a branched inflorescence.

† 303. CLAVIGERA BRACHYPHYLLA (sp. nov.): subcinereo-puberula, herbacea; caulibus humilibus (vix ped.) foliosis; foliis oblongo-ovatis integriusculis subpetiolatis triplinerviis minutim resinoso-punctatis (½ unc. longis); capitulis circ. 12-floris in ramulos subaphyllos vel pedunculos racemoso-paniculatos solitariis paucisve digestis; squamis involucri lanceolatis acutiusculis, extimis brevibus ovatis mucronatis; acheniis pubescentibus; pappo breviter plumoso. — Foot of high rocks, two miles east of the Mora River; August. (339.) — This species is remarkable for a pappus which is almost plumose to the naked eye, so as to leave as little distinction between this genus and Kuhnia, on the one hand, as there is between it and Brickellia, on the other; the difference being merely one of degree. There is an undescribed and remarkable species in Gregg's collection.

† 304. KUHNIA EUPATORIOIDES, *Linn.* Near Council Grove; August. (340 and 348.) — Perhaps the species of Kuhnia of De Candolle with pentagonal achenia and plumose pappus may be joined to Carminatia, *Moç. & Sess.*; of which fine specimens occur in Coulter's Mexican collection.

† 305. K. EUPATORIOIDES, γ. GRACILIS, *Torr. & Gray, Fl.* 2. *p.* 78. Along the Mora River; August. (342.)

† 306. BRICKELLIA GRANDIFLORA, *Nutt.; Torr. & Gray, Fl.* 2. *p.* 80: var. with the leaves unusually prolonged-acuminate. Precipitous side of a ravine, on Rock Creek, a source of the Canadian; August. (335.)

307. B. FENDLERI (sp. nov.): glabra, minute scabrida; foliis suboppositis alternisve deltoideo-cordatis acutis grosse dentatis petiolo duplo longioribus, dentibus plerum-

CLAVIGERA SPINULOSA (sp. nov.): fruticosa, ramosissima, glabrata; foliis parvis confertis lineari-lanceolatis rigidis cuspidatis spinuloso-dentatis; capitulis 5–8-floris in paniculas angustas congestis folia excedentibus; involucri squamis oblongis mucronulatis; acheniis pubescentibus; pappo barbellato. — High plain near Chihuahua; April, *Dr. Gregg.* — A very bushy under-shrub, one to two feet high. The specimens bear the leaves of the preceding year, and the branchlets are covered with naked leaf-buds, just expanding. Leaves crowded or fascicled, alternate, occasionally opposite, one half or two thirds of an inch long, spinulose with from 3 to 6 strong and sharp teeth on each side.

que calloso-apiculatis; capitulis corymboso-paniculatis parvulis pedicellis nudis sublongioribus; involucri circ. 30-flori squamis puberulis omnibus appressis obtusis; acheniis glaberrimis. — Foot of mountains on the sunny side, along the creek, eleven miles above Santa Fé; July. (347.) — Plant much smaller in all its parts than the preceding. Stem a foot or so in height. Leaves 1½ inch long, coarsely and sharply toothed, scarcely acuminate, glabrous, but minutely resinous-dotted. Heads more paniculate, barely one fourth of an inch long, with few if any loose bractlets at the base, and these conformed to the proper involucral scales, ovate, and obtuse or slightly acute. Achenia 5-angled with five intermediate nerves, which are sometimes inconspicuous.

308. B. (Bulbostylis) Californica, *Torr. & Gray, Fl. 2. p. 79*: var. foliis plerisque subcordatis. — Rocky hill-side on the Mora River, and eight miles eastward, in bottom land; Aug. (346.) — The cauline leaves are mostly cordate, and with rather longer petioles than in the Californian specimens collected by Douglas; but the plant of Hartweg's recent collection is wholly intermediate. Mr. Bentham (in *Bot. Voy. Sulph.*) has very properly carried out the intimation given in the *Flora of North America*, and annexed Bulbostylis to Brickellia. The pappus is so strongly barbellate-denticulate in some species (as in the original B. cordifolia and especially in B. cylindracea, *Gray & Engelm.*, from Texas, and an undescribed Mexican species found by Dr. Wislizenus*) that Clavigera is separated by a merely arbitrary character.†

* Brickellia (Bulbostylis) Wislizeni (sp. nov.): glanduloso-hirta; caulibus seu ramis elongatis simpliciusculis foliosis; foliis oppositis internodiis longioribus ovato-oblongis e basi subcordata arcte sessilibus argute serratis acutis lucidis undique hirtello-scabris triplinerviis subtus grosse reticulatis; ramulis floridis brevibus monocephalis in racemum laxum foliosum dispositis; involucri circ. 20-flori squamis pauciusculis 2–3-seriatis laxis omnibus lanceolatis sensim acuminatissimis, intimis attenuatis glabris pappum crebre serrulatum subæquantibus, exterioribus ⅓ brevioribus glanduloso-hirtis; acheniis sericeis. — Mountains around Cosiquiriachi, west of Chihuahua, *Dr. Wislizenus.* — Herbaceous stems, or branches, 18 inches high. Leaves thin, an inch and a half in length, the coarsely reticulated veins very prominent underneath. Heads over half an inch in length; the pappus white and copious. Corolla ochroleucous.

† There is a well-marked, undescribed Stevia in Coulter's Mexican collection, apparently resembling S. dissitifolia and S. podocephala, *DC.*, which may be thus characterized: —

Stevia trichopoda (*Harv. & Gray, ined.*): herbacea, glanduloso-pubescens; caulibus gracilibus erectis; foliis oppositis longe dissitis (inferioribus desunt) ovalibus utrinque obtusis crenatis hispido-scabris triplinerviis venosis; cyma nuda effusa; capitulis longe pedicellatis sparsis; corollis involucri squamis acutis glandulosis duplo longioribus, tubo purpurea, limbo pallida irregulari subpalmato (an semper?); acheniis glabriusculis; pappo paleaceo brevi et 3-aristato, aristis corollam adæquantibus basi submarginatis. — The leaves of the specimen are an inch, the internodes 3 to 4 inches, in length; the cyme several times dichotomous, with slender, diffusely spreading branches, dividing into monocephalous peduncles half an inch or an inch long. The awns of the pappus, as in some other species, are somewhat scarious-dilated towards the base. This dilatation is so

† 309. EUPATORIUM PURPUREUM, *Linn.* One hundred miles west of Independence; August. (344.)

much increased as to convert the awns into *paleæ* in a plant of Dr. Wislizenus's Mexican collection, which, being also somewhat peculiar in the involucre and in the great size of the flowers, may be taken as the type of a new genus, intermediate between Stevia and Palafoxia: —

CARPHOCHÆTE, *Nov. Gen.*

Capitulum 4-florum homogamum. Involucrum cylindricum; squamis 5–6, lanceolatis, parce striatis, laxe imbricatis, exterioribus brevioribus. Receptaculum nudum. Corollæ tubulosæ hypocraterimorphæ, involucrum duplo superantes, lobis oblongis glabris. Styli rami filiformes, glabri. Achenia gracilia, pentagona, glabrata. Pappus biformis, e paleis 5 brevibus cuneato-truncatis hyalinis enerviis, et 5 alternis (ex angulis achenii ortis) elongato-lanceolatis pinnato-striatis uninerviis, nervo crasso in aristam serrulatam corolla subbreviorem sensim exserente. — Herba spithamæa, glaberrima, e basi suffruticosa multicaulis; foliis oppositis et in axillis fasciculatis, elongato-linearibus, angustis, integerrimis; corymbo terminali oligocephalo; pedunculis simplicibus nudis; floribus ut videtur roseis, fere unciam longis.

C. WISLIZENI. — Mountains west of Chihuahua, near Cosiquiriachi, *Dr. Wislizenus.* — The plant is not glandular, nor sprinkled with resinous atoms, except a few on the tube of the corolla. The rigid leaves are two inches or more in length, and one line wide. The scales of the involucre are rather lax, with somewhat scarious and spreading acuminate tips. — The plants collected at Cosiquiriachi, in the Sierra Madre, are in great part new. Among them is a well-marked Eupatorium, of De Candolle's series *Eximbricata*, viz.: —

EUPATORIUM HEDERÆFOLIUM (sp. nov.): fruticosum; ramis teretibus puberulis; foliis oppositis longe petiolatis subtriangulato-cordatis obtusissimis grosse crenato-dentatis membranaceis glabellis punctatis basi trinervatis; corymbis terminalibus subsessilibus densis; capitulis breviter pedicellatis 10–12-floris; involucri squamis 9 æqualibus oblongis obtusis puberis achenia ad angulos hirtella subæquantibus. — "Cosiquiriachi, common: shrub 3 to 4 feet high: flowers white," *Dr. Wislizenus.* Leaves thin, bright green above, an inch or an inch and a half in length and breadth; the slender petiole an inch long.

The Texan plant provisionally appended to Ageratum, under the name of A.? (Micrageratum) Wrightii, along with a second species recently detected in Northern Mexico, must be considered to constitute a new genus, perhaps more nearly allied to Phalacræa, *DC.*, viz.: —

TRICHOCORONIS, *Nov. Gen.*

Capitulum homogamum multiflorum. Involucrum disco brevius, e squamis laxis 12–18 subbiseriatis æqualibus membranaceo-herbaceis constans. Receptaculum conicum, nudum. Corolla pl. m. glandulosa; tubo angusto in faucem late campanulatam 5-dentatam abrupte dilatato. Antheræ apice brevissime appendiculatæ. Styli rami exserti, lineares, complanati, obtusi. Achenia pentagona, secus angulos hispidula, pappo brevissimo multisetuloso-coroniformi sæpeque 5-aristulato superata. — Herbæ subpaludosæ vel aquaticæ, basi repentes; caulibus adsurgentibus vel emersis, ramosis, viscoso-villosis; foliis oppositis, seu ramealibus sparsis, dentatis, sessilibus, pl. m. amplexicaulibus; pedunculis gracilibus, nudis, solitariis vel corymbosis; floribus roseo-purpureis.

1. T. WRIGHTII: adscendens; foliis lanceolato-oblongis subserratis e basi lata subcordata arcte sessilibus, infimis subspathulatis; capitulis parvis (sesquilineam latis) plurimis paniculato-corymbosis; squamis invo-

†310. E. AGERATOIDES, *Linn.* One hundred miles west of Independence. (345.)

†311. E. PERFOLIATUM, *Linn.* Near Fort Leavenworth; September. (337.)

312. DIETERIA CORONOPIFOLIA, *Nutt.; Torr. & Gray, Fl. 2. p.* 101. On the Arkansas, and between Santa Fé and Pecos. (352.) — In cultivation, from Texan seeds, this proves to be a very showy annual. The heads, with the expanded bright violet-colored rays, are an inch and a half in diameter; the disk golden-yellow. The pappus is often white.

†313. ASTER LÆVIS, *Linn.; Torr. & Gray, l. c.* Valley of Santa Fé Creek, at the foot of mountains, nine miles above the town. (362.)

†314. A. AZUREUS, *Lindl.; Torr. & Gray, l. c.* Prairies on the Kansas River. (366.)

†315. A. SAGITTÆFOLIUS, *Willd.; Torr. & Gray, l. c.* Council Grove, &c. (357.)

316. A. SERICEUS, *Vent.* Council Grove, &c.; September. (355.)

✓ †317. A. FENDLERI (sp. nov.): caulibus spithamæis e caudice sublignosa pluribus adscendentibus rigidis parce hispidulis; ramis corymboso-paniculatis monocephalis; foliis sessilibus rigidis coriaceis parvis linearibus mucronulatis integerrimis glabris uninerviis marginibus hispido-ciliatis, infimis subspathulatis, ramealibus brevissimis; involucri campanulati squamis 3-seriatis lineari-oblongis glanduloso-scabrellis mucronulatis, exterioribus herbaceis obtusis laxis, interioribus acutis paulo longioribus; acheniis pubescentibus. — On the Ocaté Creek and the Rio Colorado (Upper Canadian); Aug. (372.) — A low species, of the group *Ericoidei*, or perhaps *Amelli*, with much the aspect of Diplopappus

lucri lineari-oblongis acutiusculis; tubo corollæ fauce breviore; pappo e setulis plurimis subcoroniformi-concretis et sæpe 5-aristellatis. — AGERATUM? (MICRAGERATUM) WRIGHTII, *Torr. & Gray, ined. in Proceed. Amer. Acad.* 1. *p.* 46. — Low places in the prairies along the Colorado River above Columbus, Texas, *Mr. Charles Wright.* — A span to a foot high; the stems very leafy, much branched. Leaves 6 to 8 lines in length.

✓ 2. T. RIVULARIS (sp. nov.): fluitans; ramis emersis; foliis obovato-spathulatis sinuato-incisis grosse-dentatisve basibus longe angustatis connato-amplexicaulibus; pedunculis solitariis vel binis monocephalis; capitulo majusculo (3–4 lin. lato); squamis involucri circ. 12 ovalibus obtusissimis; tubo corollæ gracili faucem subhemisphæricam æquante; pappo exaristato. — In springs and small flowing streams, Monterey and Cerralbo, *Dr. Gregg, Dr. Edwards.* On the Mexican side of the Rio Grande above Presidio, *Mr. Wright.* — A near ally of the preceding, but truly aquatic; the stems somewhat succulent. Leaves one or two inches long, with a few coarse and obtuse teeth. The flowers are said to be yellow by Dr. Gregg, but they do not appear to be so in the specimens; and Mr. Wright pronounces them to be purple. The pappus consists of numerous minute setæ, rather than squamellæ, which are more or less confluent or coroniform-united at the base, just as in T. Wrightii, but there is no trace of any stouter bristles or awns. These plants certainly do not belong to Ageratum; but if the divisions Alomieæ and Agerateæ of De Candolle are to be combined, this genus should stand next to Phalacræa, *DC.*

linariifolius. The longer leaves are only three fourths of an inch in length. Involucre one fourth of an inch in diameter. The rays have apparently been violet or blue.

†318. A. MULTIFLORUS, *Ait.* On the Arkansas and Kansas. (368.)

†319. A. MULTIFLORUS, γ. COMMUTATUS, *Torr. & Gray, l. c.* Rock Creek, New Mexico; August. (367.)

320. A. SIMPLEX, *Willd.; Torr. & Gray, l. c.* Santa Fé; July, August. (360.)

†321. A. CARNEUS, *Nees, Ast. p.* 96. On the Arkansas; September. (370.)

†322. A. MISER, γ. DIFFUSUS, *Torr. & Gray, Fl. 2. p.* 130. Bottoms beyond the upper ferry of the Kansas River; September. (365.)

†323. A. n. sp.? allied to A. longifolius and A. anomalus; a single specimen, too incomplete for safe description. Two miles east of the Mora River; August. (364.)

†324. A. OBLONGIFOLIUS, *Nutt.* Prairies and creek-bottoms, Council Grove; September. (369.)

†325. A. OBLONGIFOLIUS, *Nutt.;* a dwarf variety. Rock Creek, New Mexico; August. (371.)

†326. A. (OXYTRIPOLIUM) DIVARICATUS, *Torr. & Gray, Fl. 2. p.* 163. Arkansas bottom; September. (363.)

327. ERIGERON CANADENSE, *Linn.* Santa Fé Creek; July to October. (377.)

†328. E. DIVARICATUM, *Michx.* On the Arkansas; September. (382.)

†329. E. BELLIDIASTRUM, *Nutt. in Trans. Amer. Phil. Soc. (n. ser.) 7. p.* 307. Near the ford of the Cimarron and Willow Bar, in deep sand; Aug. (383.) — Dr. Wislizenus also collected it at the northern extremity of the Jornado de Muerto.

330. E. MACRANTHUM, *Nutt.! l. c.; Torr. & Gray, Fl. 2. p.* 173. Mountains, Santa Fé Creek, eleven miles above the town; July. (384.) — The stem bears a few scattered bristles; the flowering branches are a little glandular, as well as the involucre; and the cauline leaves are acute. It therefore connects the E. macranthum of Nuttall with the var. β.

331. E. MACRANTHUM, β. *Torr. & Gray, l. c.* Mountain-sides, ten miles above Santa Fé; July. (376.) — A span high, the branches and peduncles glandular.

332. E. CANUM (sp. nov.): pumilum; caulibus e radice crassa multicipitibus cæspitosis inferne foliosissimis monocephalis foliisque lineari-spathulatis integerrimis undique sericeo-incanis; ligulis albis subuniseriatis involucrum albo-hirsutum duplo superantibus; acheniis glaberrimis; pappo radii et disci conformi duplici, exteriore brevissimo e setis subulato-setaceis. — Dry places, on gravelly hills and at the foot of mountains, Santa Fé; May, June. (375.) — Stems 3 or 4 inches high, apparently forming dense tufts, from a thick perennial root, simple, leafy to the summit, their caudiciform bases imbricated with

the persistent vestiges of former leaves. The foliage, like the stems, is uniformly whitened with a thick and closely appressed silky-hirsute pubescence; the lowest leaves an inch or more in length, including the long tapering base or petiole, the upper shorter, more sessile, and nearly linear, less than a line in width. Head, rays, &c., very like those of E. pumilum. Scales of the involucre somewhat in two series, almost equal. Inner pappus of rather copious, strongly scabrous bristles. — This striking species should probably rank with E. pumilum and E. concinnum in the section Stenactis, *Torr. & Gray, l. c.*, rather than in Pseuderigeron.*

333. E. CINEREUM (sp. nov.): bienne? undique molliter cinereo-pilosum; caule e basi ramoso; ramis adsurgentibus apice longe nudis monocephalis; foliis spathulatis vel lineari-oblongis basi attenuatis integerrimis seu radicalibus paucidentatis incisisve; ligulis numerosissimis gracilibus (albis nunc purpureo tinctis) involucrum hirsutum duplo superantibus; pappo radii et disci conformi duplici, exteriore coroniformi-squamellato, interiore e setis sub-20 fragilibus deciduis. — Var. *α.* is a dwarf, vernal form, only a span high, quite hoary, the primary flowering stems erect and almost scapiform (no. 374 of the distribution). Dry, exposed places around Santa Fé; May. Var. *β.* has taller and more diffuse stems (10 inches high), the leaves almost lanceolate, entire, the lower tapering into slender petioles. Low, sandy banks of the Rio del Norte and of Santa Fé Creek: May to June. (380.) Var. *γ.* is a larger, coarser, and much more leafy state; from the valley of Santa Fé Creek, near irrigating ditches; May to July. (385.) — The heads are as large as those of Bellis perennis, solitary on peduncles, or the naked summit of the stems, of from 2 to 4 inches in length. The species belongs to the first division of the section Phalacroloma, *Torr. & Gray, l. c.*† Some forms of this, or of an allied species (possibly E. affine, *DC.*), with rather less numerous and white rays, and either entire or incised leaves, were gathered at Buena Vista and Encantada by Dr. Gregg.

334. E. FLAGELLARE (sp. nov.): bienne? striguloso-puberulum, pumilum; caulibus gracillimis e basi ramosis, floriferis seu primariis simplicibus superne aphyllis monocepha-

* A Texan species which I refer to the same section is probably Distasis modesta, *DC.*, although the squamellæ and fragile setæ of the pappus are more numerous than in De Candolle's character.

ERIGERON MODESTUM: hirsuto-pubescens, cinereum; caule ramosissimo paniculato-corymboso; ramis monocephalis; foliis subspathulatis linearibusve basi attenuatis imis petiolatis integerrimis; ligulis 30–40 uniserialibus (albis) involucrum canescenti-hirsutum duplo superantibus; acheniis parce pilosulis; pappo radii et disci conformi duplici, exteriore paleaceo-squamellato, interiore e setis fragilibus circiter 12. — Distasis modesta, *DC. Prodr.* 5. *p.* 279? — New Braunfels, Texas, *Lindheimer.*

† From Mr. Lowell's herbarium I find that Dr. Gambell gathered the same species in the vicinity of Santa Fé.

lis, sterilibus patentibus flagelliformibus; foliis spathulatis mucronulatis inferioribus in petiolum gracilem attenuatis integris seu radicalibus parce inciso-lobatis, ramealibus parvulis sublinearibus sessilibus; ligulis numerosis gracilibus (albis purpureo tinctis) involucrum hirsutum duplo superantibus; pappo radii et disci conformi duplici, exteriore coroniformi-squamellato conspicuo, interiore e setis sub-20 fragilibus.—Low, moist places, along Santa Fé Creek; May, June. (381.)—Root slender. Flowering stems 5 to 7 inches high, very slender, few-leaved below the middle, naked and pedunculiform above; the head rather smaller than in the preceding species; the involucre, &c., similar. Lower leaves one to two inches long, including the slender petiole; those of the runner-like sterile branches decreasing to 2 or 3 lines in length. This species should rank next to the foregoing.*

335. DIPLOPAPPUS ERICOIDES, *Torr. & Gray, Fl. 2. p.* 182; & β. HIRTELLA: foliis laxis linearibus vel inferioribus spathulatis scabro-glandulosis non strigosis valde hispido-ciliatis. — Sides of ravines in arid places, Santa Fé; also on the Rio del Norte; May, June. (348.) — A tufted, Heath-like, suffruticose plant, of a span or less in height, apparently subject to considerable variation in the foliage; the leaves being sometimes all appressed, linear-subulate or acerose, and hoary with appressed hairs; sometimes less hoary, but showing a close glandulosity; or again (of which the var. β. exhibits the most marked form) with the leaves loose or a little spreading, destitute of appressed hairs, but more glandular, and conspicuously fringed with hispid bristles, the longer ones half an inch in length, the lowest strictly spatulate. The same species, in one or two forms, was gathered in arid places, at Albuquerque, by Dr. Wislizenus, and at Chihuahua and Buena Vista by Dr. Gregg. The outer pappus is inconspicuous, and consists of a few very slender, short setæ. The rays are white, sometimes tinged with purple. — At Buena Vista, Dr. Gregg also collected what I take to be a mere variety of this species, with "yellowish" rays.

336. TOWNSENDIA SERICEA, *Hook.! Fl. Bor.-Am. 2. p.* 16. *t.* 119. β. PAPPOSA. Santa Fé, on arid hill-sides, less frequently in grassy places; April, May. (349.)—These are fine specimens of the original type of this well-marked genus, with the sessile heads fully as large as in Richardson's and Drummond's specimens (the larger almost an inch in length), and agreeing with them, except that the rays are more fully explanate

* Erigeron decumbens, *Nutt.*, communicated by Mr. Spalding, from the Kooskooskee, Oregon, has bright purplish-blue rays. He also sends E. ochroleucum, *Nutt.*, which is the same as no. 203 of Geyer's Oregon collection. No. 30 of the same collection consists, in my set, of E. pumilum, with E. cæspitosum, β. grandiflorum. I mention this, because some transposition or confusion in respect to these numbers must have occurred either in the distribution of the specimens or in the published enumeration.

and exserted (half an inch long, linear, plane when in flower), and the pappus of the ray is copious and similar to that of the disk! — The achenia of all the species, and especially of the annual or biennial ones, are callous-margined, as in Calimeris proper, and the bristly hairs they bear are minutely capitate or glochidate.

337. T. FENDLERI (sp. nov.): biennis? vel perennis, caulescens; strigoso-incana; foliis linearibus elongatis; squamis involucri lanceolato-oblongis acutiusculis late scariosis ciliatis; ligulis lineari-oblongis involucrum duplo superantibus; pappo fl. radii minuto squamellato, disci multisetoso corollam æquantibus achenio sublongioribus. — Gravelly hill-sides, Santa Fé; May to August. (350.) — Probably perennial; the caudex branching, sending up stems of an inch or little more in height, which are simple or branching, and sparingly leafy up to the head. Leaves all linear, slightly dilated upward, less than a line broad at the summit, an inch long; the uppermost, as is usual in the genus, close to the head. Involucre one fourth of an inch in diameter. Rays blue or white, spreading. Bristles of the pappus subulate-setiform, scabrous. — This species most resembles T. Fremontii, *Torr. & Gray*, but is more caulescent, with longer and narrower leaves, the pappus shorter and less denticulate; that of the ray much reduced, as in T. strigosa.

338. T. STRIGOSA, *Nutt. l. c.* Gravelly hills, Santa Fé; May. (351.) — This has a slender, annual root, or rather biennial, as it flowers in the spring. The earlier radical leaves are short, spatulate, and smoothish. Heads less than half an inch broad; the primary ones raised on a nearly naked scape or peduncle half an inch or so in length.*

†339. T. GRANDIFLORA, *Nutt. l. c.* Low prairie, between Ocaté Creek and the Rio Colorado; August. (533.)

340. T. EXIMIA (sp. nov.): hirsuto-pubescens; caulibus e radice annua seu bienni crassa erectis subsimplicibus; foliis spathulato-oblongis oblanceolatisve crassiusculis ciliatis glabratis, summis ad capitulum maximum approximatis eumque sæpius brevioribus; squamis involucri ovato-lanceolatis acuminatissimis late scariosis fimbriolato-ciliatis; ligulis

* I subjoin the characters of an allied species from a more southern region: —

TOWNSENDIA MEXICANA (sp. nov.): strigoso-incana; caulibus e radice annua seu bienni plurimis (2–3-uncialibus) cæspitosis gracilibus diffusis ramosis; foliis spathulato-linearibus majoribus nunc 1–2-dentatis; capitulis pedunculatis primariis longe pedunculatis ebracteatis; involucri squamis oblongis obtusis biseriatis æquilongis, exterioribus anguste scarioso-marginatis; ligulis linearibus patentibus involucrum plusduplo superantibus; pappo fl. radii coroniformi-multisetoso achenio 4-plo breviore, setis tenerrimis glochidato-capitatis; fl. disci e setis circ. 24 subulatis inæqualibus minute barbellatis acheniam corollamque vix æquantibus. — "Saltillo; March. Called *Pimentilla;* used for tooth-wash. Flower white." *Dr. Gregg.* — In the specimens, some of the rays seem to have been bluish or purplish underneath. Heads smaller than in T. strigosa. The delicate bristles of the ray pappus are minutely glochidate, like the hairs of the achenium, and some of them bear one or two lateral decurved teeth.

(cæruleis vel albis) angusto-linearibus involucrum subduplo superantibus; pappo persistente e paleis crassis cartilagineis uniserialibus basi concretis coroniformi, fl. radii brevissimo subæquali, disci inæquali, paleis 1–3 in squamellis aristiformibus productis corollam atque achenium late obovatum calloso-marginatum pl. m. brevioribus. — Sides of high mountains, Santa Fé Creek, and prairies on the Mora River; June to Aug. (353). — The most striking species of the genus; the upright stems 6 or 7 inches high from a strong tap-root, terminated by solitary heads resembling those of T. grandiflora or still larger (an inch in diameter). Lowest leaves 2 inches long; the upper successively smaller and more sessile. Ray achenia fertile, narrower than those of the disk, which are a line and a half in length, flat, with thickened callous margins. The pappus is of a much firmer texture than in the other species, more paleaceous, the scales few, coroniform-concreted, and perfectly persistent; the 1 to 3 longer ones (of the disk) subulate-aristiform, half or two thirds the length of the mature achenium. — Lieut. Abert also gathered this species on Purgatory River.

†341. EGLETES HUMILIS, *Torr. & Gray! Fl. 2. p.* 411, in obs. (Leucopsidium humile, *Benth. Pl. Hartweg, p.* 18.) Valley of Santa Fé Creek; May. (373.) — This is also in Dr. Gregg's North-Mexican collection. The plant is more canescent and the heads smaller than in E. Arkansana, and the pappus, as noted in the *Fl. N. America, l. c.*, is a small crown, the edge of which is evenly cleft into a fringe of numerous setulose teeth. The tube of the disk corolla sometimes becomes thickened and indurated at the base, as in E. Arkansana.*

* It is difficult to say whether this genus should be referred to the Anthemideæ or the Asteroideæ; but if Leucopsidium, *DC.*, has been correctly joined to it, so likewise should be Aphanostephus, *DC.*, which differs in no character of any generic consequence. In E. RAMOSISSIMA (Aphanostephus ramosissimus, *DC.*, and also A. Riddellii, *Torr. & Gray*) the coroniform pappus is minutely fringed, just as in E. humilis. I have had it in cultivation for two years, along with E. Arkansana, with which it well accords in habit. The heads are smaller, but more numerous, and are borne in profusion throughout the summer; the rays are white, and usually finely tinged with pink or purple underneath. I have not observed any thickening of the disk-corollas. — I no longer doubt that Keerlia skirrobasis of De Candolle is founded on a depauperate state of Egletes Arkansana. Dr. Gregg collected specimens of E. ramosissima at Monterey and Buena Vista. — I subjoin the characters of some new heterochromous Compositæ-Asteroideæ of Northern Mexico.

PSILACTIS, *Nov. Gen.*

Capitulum multiflorum, radiatum, heterochromum; fl. radii ligulatis, numerosis, uniseriatis, fœmineis; disci tubulosis hermaphroditis. Involucrum disco brevius, e squamis lanceolatis subherbaceis imbricatum, 3–4-seriale. Receptaculum convexum, subalveolatum. Ligulæ 60–80, elongatæ, angusto-lineares. Corollæ disci 5-dentatæ. Styli rami breves, appendice triangulari acutiuscula complanata hirtella terminati. Achenia

342. Guttierrezia Euthamiæ, *Torr. & Gray, Fl. 2. p. 193.* Bent's Fort, on the Arkansas; and at Santa Fé, on gravelly hills; Aug. to Sept. (388.)

oblonga, puberula. Pappus radii nullus; disci pilosus, uniserialis, corolla brevior, setis scabris. — Herbæ Mexicanæ, graciles, annuæ, subviscosæ, erectæ, ramosæ; ramis laxe paniculatis monocephalis; foliis linearibus; capitulis parvis; ligulis cæruleis, disco flavo.

1. P. asteroides: ramis capitulisque viscoso-pubescentibus; foliis integerrimis; involucri squamis linear-lanceolatis subæqualibus 2–3-seriatis laxis; ligulis elongatis; pappo corolla disci paulo breviore e setis circ. 18 fere æqualibus. — Llanos, in the Sierra Madre, west of Chihuahua, *Dr. Wislizenus.* — Stem two feet high, slender. Cauline leaves 1 or 2 inches long, seldom 2 lines wide, membranaceous, somewhat pubescent and ciliate, mucronulate; those of the branchlets small, more pubescent and viscous-glandular. Heads about as large as in Aster ericoides; the involucre rather to be compared with that of Aster Novæ-Angliæ, equally glandular. — This genus would stand between Dieteria and Aster, except from the want of pappus in the ray, which would refer it to De Candolle's subdivision Heteropappeæ with the character a little enlarged. — I have flowering branches of a second species, from Coulter's Mexican collection, viz.: —

2. P. Coulteri: subglabra; foliis (ramealibus) rigidiusculis plerisque dentatis; involucri squamis 3–4-seriatim imbricatis inæqualibus oblongo-lanceolatis obtusiusculis vix glandulosis; pappo corolla disci tertia parte breviore, e setis circ. 40 valde inæqualibus. — Mexico, *Coulter*, no. 295.

ACHÆTOGERON, *Nov. Gen.*

Capitulum multiflorum, radiatum, heterochromum; fl. radii ligulatis, numerosissimis, pluriseriatis, fœmineis; disci tubulosis hermaphroditis. Involucrum subbiseriale, e squamis æqualibus linearibus dorso villosis. Receptaculum convexum, subalveolatum. Ligulæ circ. 400, elongatæ, lineari-filiformes. Corollæ disci 5-dentatæ. Antheræ cuspidato-apiculatæ. Styli rami breves, cono brevissimo complanato terminati. Achenia (immatura) oblonga, compressa, 4-nervia, parce hirtella. Pappus in disco et radio conformis, simplex, e paleis 5–6 laciniato-denticulatis basi in coronam achenio quadruplo breviorem concretis. — Herba perennis, hispida, facie Erigerontis pumili; caulibus simplicibus monocephalis; ligulis albis, disco flavo.

A. Wislizeni. — Llanos, in the Sierra Madre, west of Chihuahua, in an open valley, among grass. — Stems 10 inches high, erect or ascending, rough-hirsute, slender, leafy nearly to the summit. Leaves alternate, linear, somewhat 3-nerved; the upper sessile and entire; the lower sparingly incised-toothed, tapering to the base. Head three fourths of an inch in diameter, including the rays, which are 3 or 4 lines long, excessively numerous, and very slender. Pappus nearly equalling the proper tube of the corolla. — The plant is entirely like a true Erigeron (so much so, that, except for the more numerous rays, it might be taken for E. pumilum, *Nutt.*), except as to the pappus, which refers it to the Bellideæ, *DC.*, and is remarkably large and conspicuous for that subdivision. It represents, as it were, the section Phalacroloma deprived of the bristles; in allusion to which character the generic name is contrived.

DIPLOSTELMA, *Nov. Gen.* (non *Raf.*)

Capitulum multiflorum, hemisphæricum, radiatum, heterochromum; fl. radii uniserialibus, fœmineis; disci tubulosis hermaphroditis, omnibus fertilibus. Involucrum pluriseriale; squamis lineari-oblongis, coriaceo-chartaceis, subcarinatis, margine scariosis, apice fimbriato-ciliatis, regulariter imbricatis, appressis, exterioribus sensim brevioribus. Receptaculum planum, nudum. Ligulæ circ. 20, elongatæ. Corollæ disci (plusquam

313. G. (HEMIACHYRIS) SPHÆROCEPHALA (sp. nov.): humilis, diffuso-ramosissima: ramulis divergentibus foliosis capitula solitaria majuscula gerentibus; foliis linearibus uni-

60) e tubo gracili infundibuliformes, limbo 5-lobo. Styli rami complanati, appendice triangulari acutiuscula terminati. Achenia oblonga, compressa, hirtella, radii subtrinervia, disci binervia, nervis marginalibus. Pappus conformis, duplex, e paleis coriaceis 5 oblongis eroso-truncatis achenio brevioribus, et setis capillaribus scabris totidem cum paleis alternantibus corollam subæquantibus, constans. — Herba annua biennisve, pumila, Bellidis-facie, cinereo-hirsuta; caulibus e basi simplicibus monocephalis; foliis obovatis vel spathulatis integerrimis, caulinis parvulis; capitulo majusculo; ligulis albis; disco luteo.

D. BELLIOIDES. — Monterey and Buena Vista, *Dr. Gregg*, *Dr. Edwards*, and *Major Eaton:* apparently in dry soil; flowering in March. — Plant 2 or 3 inches high, branched from the base; the stems simple or nearly so, leafy to the top. Radical leaves an inch long, including the tapering base or petiole; the cauline successively smaller, sometimes minute. Involucre one fourth of an inch in diameter, pubescent with fine appressed hairs. Rays linear-oblong, about a fourth of an inch in length, the tube (as also that of the disk corollas) slender. — This genus belongs to the subdivision Bellieæ, *DC.*, where it will stand between Bellium (which it seems to represent in the New World) and Chætopappa. The achenia and pappus are nearly as in Bellis, from which it is distinguished principally by the perfectly flat receptacle, the pluriseriate imbricated involucre, the manifest tube to the corolla, and the leafy stems. From Chætopappa it differs in the many-flowered heads with a hemispherical involucre, the flowers all fertile, in the flattened and 2-nerved achenia, and the large and thickish scales of the pappus. To avoid an increase of synonymy in case the discovery of intermediate forms should invalidate these distinctions, I have taken up for the name of this genus a superseded synonyme of Chætopappa.

DICHÆTOPHORA, *Nov. Gen.*

Capitulum multiflorum, radiatum, heterochromum; fl. radii ligulatis, uniseriatis, fœmineis; disci tubulosis hermaphroditis. Involucrum subuniseriale disco brevius; squamis æqualibus, lineari-lanceolatis, herbaceis, margine subscariosis. Receptaculum ovato-conicum, nudum. Ligulæ 16–20, oblongo-lineares. Corollæ disci 5-dentatæ. Styli rami appendice triangulari-lanceolata complanata terminati. Achenia (lateraliter) plano-compressa, ala suborbiculari cincta, marginibus cum disco pilis glochidatis hispidissima. Pappus radii et disci conformis, e squamellis minimis paucis (8–10) basi coroniformi-subconcretis, et setis tenellis subulatis achenio dimidio brevioribus, constans. — Herba annua, pumila, caulescens, pilosa, Bellidis integrifoliæ facie; caulibus diffusis apice nudo monocephalis; foliis spathulatis integerrimis; ligulis albis roseisve; disco flavo.

D. CAMPESTRIS. — (Brachycome xanthocomoides? *Torr. & Gray, Fl.* 1. *p.* 190.) Around Monterey, New Leon, and on the Rio Conchos, Chihuahua (the latter a more slender and less hirsute form), called "Manzanilla del campo," *Dr. Gregg.* — Stems branched from the base, 3 to 6 inches long. Heads like those of Bellis integrifolia, but the disk more conical in fruit: the receptacle longer than the involucre. Achenia half a line long, obovate-orbicular; the wing on each side as broad as the disk, strongly and densely fringed with minutely glochidate bristles: these are longer than the subulate squamellæ of the pappus, which they nearly conceal, but scarcely half the length of the two slender and naked subulate awns. — A comparison with the fragment of the Texan specimen in my possession convinces me that this is the plant which is doubtfully referred to Brachycome xanthocomoides, *Less.*, in the *Flora of North America;* the characters of which

nerviis, caulinis obtusis deorsum attenuatis; involucro hemisphærico vix pedunculato: ligulis 10–12 lineari-oblongis, fl. hermaph. circiter 30; acheniis junioribus turbinatis sericeo-villosis disci et radii pappo conformi donatis, e paleis 5–6 ovatis brevissimis pl. m. coroniformi-concretis. — Low prairie, from the Upper to the Middle Spring of the Cimarron; Aug. (527.) — Plant a span to a foot high, slightly glandular-scabrous, divergently much branched, very leafy. Cauline leaves less than an inch long. Heads about as large as those of Amphiachyris dracunculoides; the rays rather large, and spreading. Receptacle conical, alveolate-dentate. Pappus shorter than the ovary, or than the proper tube of the corolla; that of the rays similar, or very little smaller. — This species, and the nearly allied Hemiachyris glutinosa, *Schauer in Linnæa*, 19. *p.* 724 (or at least a plant of Coulter's Mexican collection which I take to be that species, notwithstanding it presents an evident, though smaller, pappus in the ray), agree with Hemiachyris, *DC.*, in the short and somewhat coroniform pappus, and in the solitary heads: but differ from Texana, *DC.*, in having a pappus also in the ray; and thus confirm the propriety of reducing that genus to a section of Guttierrezia.*

†344. Amphiachyris dracunculoides, *DC.; Torr. & Gray, l. c.* High prairies, near the upper ferry of the Kansas River; Sept. (528.) — Cultivated in the Botanic Garden, this proves to be quite an ornamental plant.

†345. Solidago speciosa, *Nutt.; Torr. & Gray, Fl.* 2. *p.* 205. With the last. (531.)

346. S. speciosa, *β.* angustata, *Torr. & Gray, l. c.* Mountain-sides, Santa Fé Creek; July. (387.)

†347. S. rigida, *Linn.* Council Grove, &c.; Aug., Sept. (389.)

†348. S. ulmifolia, *Muhl.; Torr. & Gray, l. c. p.* 217. Prairie, south of the upper ferry of the Kansas River; Sept. (530.)

were drawn from a single head of unexpanded flowers, with the setæ of the pappus and the form of the achenium not yet developed. The genus should evidently stand between Boltonia and the Australian genus Brachycome.

* The original Guttierrezia linearifolia, *Lag.*, if truly Mexican, has not been identified. From the imperfect character, I suspect it may be the Brachyris divaricata, *Nutt.*, which sometimes has only three or four rays, and which Lieut. Emory collected in New Mexico. The G. linearifolia, *Hook. & Arn. in Comp. Bot. Mag.* 2. *p.* 51 *& p.* 254, from Chili, does not agree with Lagasca's character, and is very near G. Californica. G. microcephala, the Brachyris microcephala, *DC.*, non *Hook.*, which was gathered at Saltillo by Dr. Gregg, has only one or two rays and as many disk-flowers: the pappus of the ray consists of oblong and distinct paleæ, much shorter than the achenium: that of the disk is formed of similar, although more slender, paleæ; but the achenium appears to be abortive, as in Amphiachyris, thus invalidating the distinction between those two genera.

†349. S. INCANA, *Torr. & Gray, Fl. 2. p. 221* : var. racemis dense corymbosis ; foliis plerisque acutis. — Seven miles east of Rock Creek, a source of the Canadian ; August. (525.)

350. S. INCANA, verging to S. nemoralis, *γ. Torr. & Gray, l. c.* Santa Fé ; July. (387 b.) — A well-marked dwarf state of S. incana, only a span high, with roundish leaves, but less hoary than the plant of Nicollet, was collected on the Upper Arkansas in Fremont's third expedition.

351. S. LANCEOLATA, *Linn.* Council Grove to the ferry of the Kansas. (529.)

†352. LINOSYRIS GRAVEOLENS, *β. Torr. & Gray, Fl. 2. p. 234.* Dry, gravelly hills, Bent's Fort, on the Arkansas ; Sept. (341.) — "Shrub 2 to 4 feet high." — The Linosyris Texana, *Torr. & Gray, l. c.*, was founded on specimens which prove to be masculine individuals of a nearly herbaceous species of Baccharis.*

353. APLOPAPPUS (BLEPHARODON) SPINULOSUS, *DC.* Gravelly or sandy soil, around Santa Fé, Pecos, &c. ; May to Oct. (499.)

†354. A. SPINULOSUS, var. GLABER. Prairie on the Cimarron. (394.) — Dr. Wislizenus gathered the same form on the Arkansas.

†355. A. SPINULOSUS, var. CANESCENS. Between Santa Fé and the Rio del Norte ;

* BACCHARIS TEXANA : glabra ; caulibus plurimis herbaceis e basi suffruticosa rigidis argute striato-angulatis foliosissimis subsimplicibus apice corymboso-oligocephalis ; foliis linearibus mucronulatis vel acutatis basi angustata sessilibus carinato-uninerviis marginibus obsolete repando-denticulatis ; involucri squamis lineari-lanceolatis sensim acutis laxis ; receptaculo nudo alveolato-dentato ; acheniis oblongo-fusiformibus glaberrimis pappo albido involucrum duplo excedente superatis. (Linosyris Texana, *Torr. & Gray, Fl. 2. p. 232.*) — Dry prairies and Post-oak woods, Texas, *Drummond, Dr. Riddell, Lindheimer, Wright ;* Aug. to Nov. — Stems about a foot high, in aspect not unlike Linosyris vulgaris. Leaves an inch or an inch and a half long, one or two lines wide, rigid. The sterile stems or branches bear six or eight about 30-flowered heads in a leafy corymb ; the limb of the corolla is deeply 5-cleft ; the branches of the style terminated by conspicuous lanceolate appendages. The fertile stems bear from two to eight heads ; the corollas slender and truncate ; the soft pappus half an inch long. Achenia several-ribbed. The species appears to be allied to B. thesioides, *H. B. K.*, and B. linifolia, *DC.*

The Polypappus sericeus, *Nutt. in Jour. Acad. Philad. (n. ser.)* 1. *p.* 178, from Gambell's collection, is undoubtedly the same as a Willow-like silky-cinereous shrub in Fremont's, Coulter's, and, more recently, in Emory's Californian collections, which I had ventured to refer to Tessaria. (T. borealis, *Torr. & Gray, Fl. Suppl. Compos. ined.*) In habit and generic characters it well accords with T. absinthioides, *DC.*, except that the receptacle is not hirsute, but naked. It is certainly excluded from Polypappus, and from the Baccharеæ, by the caudate anthers (although the tails are short) and heterogamous heads, there being several perfect or male flowers in the centre of the disk. Lieut. Emory met with it in the bed of the Rio del Norte, New Mexico, as well as along the Gila. It is enumerated, but not described, in his Report, under the name of Tessaria borealis, *DC.*, the initials of De Candolle having been appended through some mistake.

May. (395.) — Dwarf, more hoary than in the ordinary plant, from which I cannot separate it. It is the same as the A. (Blepharodon) Coulteri, *Harv. & Gray, ined.*, from California. — Other forms, which I cannot distinguish specifically, were gathered around Saltillo by Dr. Gregg.

† 356. A. GRACILIS: pilosus, humilis; caulibus e radice bienni ramosis; foliis inferioribus parce pinnatifidis segmentis oblongis obtusis, superioribus integris linearibus subdentatis, dentibus pulchre setigeris; ramis monocephalis; involucri campanulati squamis 3–4-seriatis lineari-lanceolatis setigero-mucronatis pilosulis; ligulis 15–18; receptaculo valde fimbrillifero, fimbrillis setoso-subulatis achenia subcompressa sericea fere æquantibus; pappo e setis valde inæqualibus, intimis rigidis basim versus incrassatis corollam subæquantibus, exterioribus gracilibus sensim dimidio–4-plo brevioribus. — Dieteria (Sideranthus) gracilis, *Nutt. in Jour. Acad. Philad. (n. ser.)* 1. *p.* 177. — Along Santa Fé Creek. (393.) — Our specimen is a very incomplete autumnal one; the pappus whitish. An original one of Mr. Gambell's, with which I have compared it, is a plant about 9 inches high, with slender branches; the linear leaves half an inch or less in length; the heads about the size of those of A. spinulosus; and the pappus rufous. It belongs to the section Blepharodon, *DC.;* but the pappus consists of as unequal and coarse bristles as in the true Aplopappi. The characters of a new Texan species of the same section, which has a still more rigid pappus, are subjoined.*

357. PRIONOPSIS CILIATA, *Nutt.; Torr. & Gray, Fl.* 2. *p.* 245. Low prairies on

* APLOPAPPUS AUREUS (sp. nov.): humilis, minute viscoso-glandulosus, primum subarachnoideus; caulibus e radice perenni? adsurgentibus diffusis; ramis ramulisve apice corymbosis monocephalis; foliis anguste linearibus scabrido-glandulosis setigero-mucronatis lobis dentibusve setigeris utrinque 1–4 instructis, summis integerrimis; capitulis nudis; involucri hemisphærici squamis oblongis pluriseriatis appressis apice brevi obtusiusculo herbaceis muticis, intimis scariosis acutis discum subæquantibus; receptaculo alveolato-fimbrillifero; acheniis brevibus turbinatis villosissimis; pappo albo e setis circiter 10 validioribus corollam subæquantibus et 20–30 sensim minoribus, omnibus rigidis. — Low prairies, near Houston, Texas, *Mr. Charles Wright;* Sept., Oct. — Stems or branches 6 or 8 inches high, terminated by a loose corymb of five or six showy heads. Lower leaves about an inch long, scarcely a line wide, the upper almost filiform. Involucre half an inch in diameter; the numerous golden-yellow rays about the same length. — Of still stouter bristles is the pappus of the subjoined rayless species, which should doubtless form a distinct subgenus, viz.: —

§ ACAMPTOPAPPUS: ligulæ nullæ: squamæ invol. hemisphærici pauciserialis oblongæ, obtusissimæ, marginibus sphacelato-scariosæ: pappus achenium et corollam vix adæquans, e setis 20–30 rigidis inæqualibus, majoribus complanatis sursum clavellato-incrassatis, constans.

A. SPHÆROCEPHALUS (*Harv. & Gray, Pl. Coult. ined.*): fruticosa? glabra; foliis caulinis ignotis, ramealibus parvis rigidis linearibus uninerviis sessilibus; capitulis (4–5 lin. diam.) 30–40-floris corymbosis breviter pedunculatis; alveolis receptaculi dentatis; achenio turbinato sericeo-villosissimo. — California, *Coulter.*

the Arkansas; Aug. to Sept. (386.) — This is a very showy plant in cultivation. From Texan seeds sown in the spring, it flowers in the autumn as an annual.

358. GRINDELIA SQUARROSA, *Dunal.* Moist meadows, &c., along Santa Fé Creek; June to Aug. (390.) — The lowest leaves are incisely pinnatifid in some specimens.*

359. HETEROTHECA SCABRA, *β.* NUDA, *Torr. & Gray, Fl. 2. p.* 251. Low prairies on the Cimarron; August. (392.) — H. (Chætactis) Chrysopsidis, *DC.*, described from specimens gathered by Berlandier at Saltillo, has also been copiously collected by Dr. Gregg at the same place. Dr. Gregg's specimens considerably resemble H. scabra, *β.*: some of the ray-flowers bear a deciduous, paucisetose pappus, while others are destitute of pappus.

360. CHRYSOPSIS VILLOSA, *Nutt.* Rocky and sunny hill-sides, valley of Santa Fé Creek; June to Aug. (391.) — The C. villosa, *β.* minor, *Hook. Pl. Geyer, in Lond. Jour. Bot. 6. p.* 244, appears to me to be C. hispida.

†361. C. CANESCENS, *Torr. & Gray, Fl. 2. p.* 256, passing into C. foliosa, *Nutt.* Dry prairies, Santa Fé to the Cimarron; July to Sept. (391 b.) — Numerous specimens from recent collections seem entirely to connect C. canescens, C. foliosa, and C. mollis. The exterior pappus is abundantly manifest in most specimens.

* Of Mr. Bentham's genus Perityle (in *Voy. Sulph. p.* 23 & 119. *t.* 15), there are the following unpublished species in Coulter's Californian collection; some of which, unlike the original species, have alternate leaves, and therefore agree better with Asteroideæ.

PERITYLE ACMELLA (*Harv. & Gray, Pl. Coult. ined.*): subglabra; caulibus elongatis decumbentibus; ramulis involucrisque minute glandulosis; foliis plerisque alternis ovatis trifidis, superioribus interdum hastato-trilobis; lobis lanceolatis oblongisve acutis; receptaculo plano; ligulis oblongis discum vix superantibus; appendicibus styli oblongo-lanceolatis acutis; pappi aristis 2 scabris tubum corollæ subæquantibus achenio oblongo marginibus valde hispidi-ciliato dimidio brevioribus. — Spilanthes Pseudo-Acmella, *Hook. & Arn. Bot. Beech. p.* 150 ?

P. LEPTOGLOSSA (*Harv. & Gray, l. c.*): suffruticosa? spithamæa, cinereo-puberula; foliis alternis (an semper?) ovatis subcordatis crenato-incisis denticulatis; receptaculo convexo; ligulis linearibus elongatis (cum tubo filiformi ½ unc. longis); appendicibus styli fl. herm. attenuato-filiformibus; pappo uniaristato, arista nuda corolla disci gracillima breviore achenio lineari-oblongo marginibus breviter hispidi-ciliato longiore.

P. PLUMIGERA (*Harv. & Gray, l. c.*): ramosissima, viscido-puberula; foliis (ramealibus) parvis alternis seu oppositis ovatis oblongisve denticulatis; receptaculo convexo; ligulis oblongis involucrum excedentibus; styli ramis fl. hermaph. elongatis in appendicem brevem vix dilatatam obtusam desinentibus; achenio oblongo marginibus villosissimo, pilis squamellis pappi longioribus; arista unica corollam disci æquante achenium plus-duplo superante apicem versus parce plumosa. — This species seems to be nearly related to P. Californica, *Benth.*, which I know only by the published description and figure. The specimens are merely branches, destitute of lower leaves. The heads are only 2 or 3 lines in diameter. The ligules are longer than the tubular portion, and much longer than is represented in the figure of the original species. The dense fringe of the achenium is nearly as broad as its disk; and the slender awn is barbellate-plumose.

† 362. C. CANESCENS, var. NANA: caulibus 3–4-pollicaribus; foliis capitulisque parvis minus incanis. — Elevated, rocky region, two miles east of the Mora River; August. (391 c.)

† 363. CONYZA SUBDECURRENS, *DC. Prodr.* 5. *p.* 379. Santa Fé, at the foot of mountains high up the creek; July. (378.) — An annual or biennial, with a strict, leafy stem, a foot high. Lower leaves pinnatifid-toothed.*

† 364. ECLIPTA ERECTA, *Linn.* Banks of the Missouri, below Liberty. (396.)

† 365. SILPHIUM INTEGRIFOLIUM, *Michx.* High prairies, near the upper ferry of the Kansas; Sept. (398.)

† 366. S. PERFOLIATUM, *Linn.* On the Kansas; Sept. (399.)

† 367. ENGELMANNIA PINNATIFIDA, *Torr. & Gray, Fl.* 2. *p.* 283. Raton Mountains; Sept. (401.) (Also near Buena Vista, *Dr. Gregg.*)

368. BERLANDIERA LYRATA, *Benth. Pl. Hartw. no.* 120. Woodlands, on the mountains, between Pecos and San Miguel; Aug. (420.) (Also on the Cimarron, *Lieut. Abert;* north of Paso, *Dr. Wislizenus;* and near Chihuahua, *Dr. Gregg.*)

† 369. MELAMPODIUM CINEREUM, *DC. Prodr.* 5. *p.* 518. (M. leucanthum, *Torr. & Gray. Fl.* 2. *p.* 271.) Santa Fé to San Miguel; Aug. (462.) — The specimen has rather large and mostly sinuate leaves, which are sometimes longer and sometimes shorter than the slender peduncles; as is also the case with plants raised from Texan seeds. It flowers all summer, and is quite ornamental. The root is apparently perennial. Also, no. † 397 from high prairies on Big Sand Creek (Cimarron), a form with narrow and entire leaves; the M. leucanthum, *Torr. & Gray, l. c.*, but certainly not distinct from M. cinereum of De Candolle. A still more slender-leaved form was gathered at Paso del Norte by Dr. Wislizenus, and intermediate states by him on the Cimarron and by Fremont on the Upper Arkansas.

† 370. IVA CILIATA, *Willd.* From Sand Creek, New Mexico, to Fort Leavenworth, in low prairies; Sept. (413.)

† 371. CYCLACHÆNA XANTHIIFOLIA, *Fresen. Ind. Sem. Hort. Franc.* 1836; *Torr. & Gray, Fl.* 2. *p.* 285. Bottom land, Santa Fé to Rock Creek, New Mexico; Aug. — Plant from 6 to 10 feet high. There are two forms (415 and 416), one with rounder and cordate, more incisely toothed leaves, the other with all the upper leaves lanceolate-ovate and somewhat cuneate at the base. The plant from Oregon, communicated by Mr. Spalding, appears to be intermediate between the two.

* The Conyza sinuata, *Ell. Sk.* 2. *p.* 378, is C. ambigua, *DC.;* as appears from specimens which I have received from Mr. Ravenel.

372. AMBROSIA CORONOPIFOLIA, *Torr. & Gray, Fl. 2. p. 291.* Santa Fé to Council Grove; Aug., Sept. (402.)

† 373. A. LONGISTYLIS, *Nutt.?* Low places, Santa Fé Creek; July, Aug. (405.) "Branches mostly decumbent, more than three feet long." Leaves all bipinnatifid. Plant just coming into flower; the fertile flowers not yet apparent. Perhaps a Franseria.

† 374. A. LONGISTYLIS, *Nutt.?* var. With the last; a stouter and more hispid form; the fertile flowers undeveloped. (407.) — Except that the leaves are more compound, it is not unlike the Mexican plant referred by De Candolle to A. Peruviana, *Willd.*

† 375. A. APTERA, *DC. Prodr. 5. p. 527.* Bottom land, Council Grove to Walnut Creek. (414.) — The upper petioles are slightly margined; but the fruit is 4 – 6-tuberculate rather than spinose.

375, bis. FRANSERIA HOOKERIANA, *Nutt.; Torr. & Gray, Fl. 2. p. 292.* (Ambrosia acanthicarpa, *Hook.*) Santa Fé, near the creek; Oct. (409.) — The fertile involucre is one-celled.*

* The spines, which are flattened and somewhat scale-like in this and some other species of Franseria, are represented by broad scarious wings in the following singular genus: —

HYMENOCLEA, *Torr. & Gray, Fl. ined., & in Emor. Report, p. 143 (absq. char.).*

Capitula monoica homogama, secus rachin persistentem glomerato-spicata. *Mas.* Involucrum Franseriæ, 5 – 6-lobum, 15 – 20-florum. Receptaculum parvum, paleis scariosis unguiculatis obovato-dilatatis onustum. Corolla cyathiformis 5-dentata. Antheræ conniventes vix connatæ, appendicula deltoidea inflexa superatæ. Ovarium vix ullum: stylus apice radiato-penicillatus. *Fœm.* Involucrum fructiferum obovoideum seu fusiformi-clavatum, coriaceum, clausum, uniloculare, uniflorum, apice in rostrum tubuliforme superne scariosum pervium desinens, extus squamis 9 – 12 magnis rotundatis scariosis persistentibus, aut spiraliter imbricatis aut univerticillatis, insigniter alatum! Corolla subnulla. Stamina nulla. Achenium ovoideum loculum implens. Semen et embryo ordinis. — Frutices Neo-Mexicani et Californici, in aridis salinis vigentes, ramosissimi, glabrati, foliosi; ramis subspinescentibus; foliis alternis, filiformibus, subtus tenuiter incanis, inferioribus pinnato-3 – 5-partitis, summis integerrimis.

1. H. SALSOLA (*Torr. & Gray, l. c.*): involucro fructifero strobiliformi angulato squamas a basi ad apicem spiraliter dispositas rotundato-reniformes basi tuberculiformi-incrassatas undique gerente. — Sandy, saline uplands near the Mohave River, in the interior desert of California, *Fremont.* — Heads spicate on short, rigid, and persistent spurs of an inch or two in length. Fructiferous involucres crowded, nearly half an inch long, covered with the broad and wing-like silvery scales, each about 4 lines wide, which are imbricated, as in a bud, and conceal the nut-like involucre from which they arise, presenting the appearance of a scaly strobile, or when moist widely spreading. This singular plant has the aspect of a Chenopodiacea rather than of a Composita, although it presents wholly the structure of Ambrosia or Franseria.

2. H. MONOGYRA (*Torr. & Gray, l. c.*): involucro turbinato-fusiformi exangulato inferne nudo versus

† 376. F. HOOKERIANA, var. foliis magis strigosis subincanis. (F. montana, *Nutt.! l. c.*) Sandy bed of Dry Creek, east of Bent's Fort; Sept. (408.)

† 377. F. DISCOLOR, *Nutt. l. c.* Between the Rio Colorado and Rock Creek, New Mexico; Aug. (411.) — Also gathered by Fremont on the Platte in the Wind River chain of the Rocky Mountains. The fertile involucres are armed with a few strong, subulate spines, one-celled, or two-celled at the base.

† 378. F. TENUIFOLIA (*Harv. & Gray, Pl. Coult. ined.*): caule erecto hispido; ramis diffusis gracilibus; foliis bipinnatisectis strigoso-hirsutis subcinereis, pinnis segmentisque 3 – 7 linearibus integris seu 1 – 2-dentatis cum lobulis paucis secus rachin angustam parce hispidam hinc inde interpositis, lobo terminali prælongo; racemis spiciformibus gracilibus in paniculam foliosam digestis: involucris masculis pedicellum æquantibus 7 – 8-dentatis 6 – 12-floris, fœmineis inferne glomeratis aculeis paucis brevissimis uncinatis armatis intus bilocellatis bifloris. — Poñi Creek, between Bent's Fort and Santa Fé; also at Santa Fé; July to Oct. (406.) — This appears to be the same as a plant in Coulter's Californian collection; and perhaps is too closely related to F. hispida, *Benth. in Bot. Voy. Sulph. p.* 25; but the lobes of the leaves are not "dentibus obtusiusculis brevibus crispis," but entire or nearly so; the sterile involucres are merely toothed, and the fructiferous involucres examined are only two-celled.

† 379. F. TOMENTOSA (sp. nov.): herbacea, pube sericeo molli undique argenteo-incana; caule erecto (pedali) paniculato; foliis pinnato-3 – 5-partitis subtus præsertim dealbatis in petiolum brevem angusto-marginatum lobulis dentiformibus hinc inde appendiculatum decurrentibus, infimis videtur bipinnatifidis, lobis superiorum et ramealium oblongis lanceolatisve dentatis seu integerrimis, nisi terminali maximo trilobo; involucris masculis in racemum densum digestis 6-dentatis 18 – 20-floris fœmineis in axillis supremis glomeratis ovoideis viscoso-puberulis aculeis subulatis validis apice subuncinatis obsitis atque 2 crassioribus rostratis intus bilocellatis bifloris. (Ambrosia tomentosa, *Nutt. Gen. 2. p.* 186?) — High banks of Walnut Creek, between Council Grove and Fort Mann, of the Arkansas; Sept. (412.) — Root perennial. Stem stout, bearing numerous paniculate branches. Leaves silvery-tomentose and very white underneath, the upper surface whitened with a less dense and somewhat deciduous pubescence; the terminal lobe from 1½ to 2½ inches in length and half an inch to an inch in width. Sterile involucre 3 lines in diameter; the fertile (immature) larger, thickly beset with short and stout

apicem squamas dilatato-obovatas basi vix crassiores in verticillum congestas gerente. — Along the valley of the Gila, *Lieut. Emory.* Also at "Ojito," New Mexico? *Dr. Gregg.* Shrub 4 or 5 feet high, with much the aspect of a Wormwood; the filiform leaves about two inches long. Fertile involucres only one fourth the size of those of the foregoing species. I have not examined the sterile heads.

spines, with two terminal and thicker, but scarcely longer ones, forming beaks, much as in Xanthium. — The vestiges of the lower cauline leaves in the specimen show that these are more or less bipinnately parted, so that the plant is likely to be the Ambrosia tomentosa of Nuttall's *Genera*, — which is known only by the incomplete character given in that work, and which has not since been recognized.

† 380. Xanthium echinatum, *Murr.*, var. fructibus minoribus. Waste fields, Santa Fé; August. (482.)

381. Zinnia grandiflora, *Nutt. in Trans. Amer. Phil. Soc. (n. ser.)* 7. *p.* 348; *Torr. & Gray, Fl.* 2. *p.* 298. Dry, gravelly hill-sides, Santa Fé; June to October. Also on Rayado Creek. (400.) — A dwarf, suffrutescent, eminently showy species, bearing an abundance of flowers through the whole season; the rounded, light-yellow rays two thirds of an inch in length, around a narrow, orange-colored disk. Some of the achenia bear a short fimbrate-laciniate awn, and a bristle or two in place of the second: others bear a little tuft of a few bristly hairs in place of the awns. The chaff is petaloid and orange-colored at the tip.*

† 382. Heliopsis lævis, *Linn.* Mora River, New Mexico; August. (430.)

† 383. H. lævis, *β.* gracilis, *Torr. & Gray, Fl.* 2. *p.* 303. Council Grove; August.† (433.)

* Dr. Torrey has re-described and figured it in Emory's Report (plate 4). The following is a very dwarf, apparently undescribed species of the same habit, from Dr. Gregg's collection: —

Zinnia pumila (sp. nov.): cæspitosa e caudice suffruticoso, depressa; caulibus 2–4-uncialibus ramosis conferte foliosis, hirsutis; foliis anguste linearibus uninerviis impresso-punctatis margine cartilagineis scabris basi connatis internodiis multo longioribus nunc fere imbricatis; capitulis parvis brevissime pedunculatis; involucri squamis rotundatis; ligulis ovalibus luteis; paleis receptaculi obtusissimis apice suberosis; acheniis disci uniaristatis aut subbiaristatis margine cum basi aristæ ciliatis. — High plain near San Juan de la Vequeria, and at Castaniola, in Northern Mexico, *Dr. Gregg.* — More dwarf and condensed than Z. grandiflora; the leaves half an inch long. Head three tenths of an inch in length; the pale-yellow rays about as long as the involucre, perhaps not persistent.

† Specimens of Heliopsis lævis, *γ.* scabra, *Torr. & Gray*, from Arkansas and farther westward, often show the rays persistent until the achenia are mature, and have an obscure coroniform pappus, much more marked than in the Eastern plant. In Mr. Spalding's Oregon collection occurs an undescribed Heliopsideous plant, which has the same relation to Balsamorrhiza that Kallias, *Cass.*, has to Heliopsis proper: —

BALSAMORRHIZA § KALLIACTIS. Ligulæ marcescenti-persistentes. Achenia pubescentia. — Caulis bi–pluriflorus, parce foliatus; foliis integerrimis.

B. Careyana (sp. nov.): cinereo-puberula, subscabra; caule erecto apice subvilloso 2–8-cephalo; foliis longe petiolatis adultis scabris reticulato-venosis, radicalibus cordato-hastatis repandis, caulinis 3–7 parvulis lanceolatis subtrinervatis sparsis imisve oppositis; involucri squamis biseriatis lanceolatis appressis villosulis æquilongis discum æquantibus; ligulis circiter 12 ovalibus emarginatis multinerviis inferne puberulis discum

384. RUDBECKIA LACINIATA, *Linn.* Along Santa Fé Creek; July. (417.)

†385. R. SUBTOMENTOSA, *Pursh; Torr. & Gray, Fl. 2. p. 309.* Near Fort Leavenworth. (419.)

ter superantibus demum papyraceis cum achenio delapsis vel tardissime articulo secedentibus; receptaculo convexo; acheniis tetraquetris apicem versus pubescentioribus prismaticis, radii modice obcompressis. — Sandy plains, Clear Water, on the Kooskooskee, Oregon, *Rev. Mr. Spalding;* flowering in May. — Root apparently thick, as in the genuine species of Balsamorrhiza. Stem from 6 to 14 inches high. Radical leaves 3 or 4, or when mature 6, inches long; the cauline 2 or 3; the petiole as long as the blade. Lateral heads on slender peduncles. Involucre half or three fourths of an inch in diameter. Rays nearly an inch long, when old apparently light yellow, raised on a short tube, the base of which is articulated with the very obtuse summit of the achenium, but is persistent until the fruit is fully ripe. Disk-corolla, style, &c., as in Balsamorrhiza. — This interesting species is dedicated to my friend Mr. John Carey, who pointed out to me its characters and affinities. Mr. Spalding's collection likewise contains the following genuine species of this characteristic Oregon genus, viz.: —

✓ B. SAGITTATA, *Nutt.* Called by the natives "*Pash.* The tender stalks, the root, and the seeds, used for food." This circumstance, the habitat, and the involucre, the exterior scales of which are longer than the others and exceed the disk, render it sure that this plant is the Buphthalmum sagittatum of Pursh; but an imperfect authentic specimen of Bals. helianthoides, *Nutt.*, does not show any marked difference. The heads in Mr. Spalding's specimens are fully four inches broad, including the extended rays. The small cauline leaves are alternate.

✓ B. INCANA, *Nutt.* Called "*Isilil.* The root, like *Kayum*, exudes a resinous juice: used for food when peeled and baked." Some of the leaves are pinnately parted; others only incised.

✓ B. TEREBINTHACEA (*Hook.*): scabro-pubescens, foliis radicalibus ovato-lanceolatis oblongisve basi truncatis vel obtusis sinuato-pinnatifidis seu integris dentatis, caulinis 2 oppositis juxta basin scapi (5 – 12 unc. longi) monocephali lanceolatis sæpe pectinato-incisis; involucro hirsuti-tomentoso pluriseriali, squamis lanceolatis attenuatis disco sublongioribus. — Heliopsis? (Balsamorrhiza) terebinthacea, *Hook. Fl. Bor.-Am.* 1. *p.* 310. —"*Kayum.* High, hard land. The bark of the root gives a turpentine, like that of pine in taste and smell. Root peeled and baked for food." — This is certainly distinct from B. Hookeri, *β. Torr. & Gray, Fl. l. c.*, to which the synonyme was doubtfully referred; and is more like B. hirsuta, *Nutt.*, but has larger and more woolly heads, and more attenuated involucral scales, as well as undivided or slightly pinnatifid leaves. The foliage, however, is extremely variable in this genus. The form which, among Mr. Spalding's specimens, best accords with Hooker's brief character, has almost undivided leaves, which are beset with very sharp and strong salient teeth. A larger variety has the radical leaves a foot long, including the petiole, and barely crenate-serrate. Involucre fully an inch in diameter. Receptacle convex. The root very thick and long.

✓ WYETHIA HELENIOIDES, viz. the Alarçonia helenioides, *DC.*, a species totally distinct from W. robusta or any other in the *Flora of N. America*, and with the fruitful head three inches in diameter, occurs in the Californian collection made by Fremont in 1846. The achenia, with the calyciform pappus, is over half an inch long. The older leaves (the radical even four inches wide) are glabrous; but those of the same species in Hartweg's collection, gathered in an earlier state, are floccose-tomentose. (I suspect that the W. ovata, briefly characterized by Dr. Torrey in Emory's Report, will prove to be the same species.)

The plant described under the name of Tetragonotheca Texana, *Gray & Engelm. in Proceed. Amer. Acad.*

386. Lepachys columnaris, *Torr. & Gray, Fl. 2. p.* 315. Between Santa Fé and Pecos; Aug. (423.)

387. L. columnaris, *β.* pulcherrima, *Torr. & Gray, l. c.* Valley west of Pecos; August. (422.)

388. L. columnaris, *β.* pulcherrima; the dwarf form, with very narrow divisions to the leaves, much branched stems, short peduncles, oval or barely oblong disk, and small rays. (Rudbeckia Tagetes, *James!* R. globosa, *Nutt.!*) — Waste fields, &c., Santa Fé: prairies, Ojo de Bernal and Poñi Creek; July to Oct. (424.)

389. Helianthus lenticularis, *Dougl. in Bot. Reg. t.* 1265. Waste places along Santa Fé Creek; June, July. (428.)

†390. H. petiolaris, *Nutt.* On the Cimarron; Aug. (429.)

†391. H. orgyalis, *DC. Prodr. 5. p.* 587 (excl. syn.). Low prairie, Hickory Point, Western Missouri; Aug. (434); the heads scarcely formed. Well distinguished by the slender leaves and attenuated long-awned scales of the involucre.*

†392. H. rigidus, *Desf.; Torr. & Gray, Fl. 2. p.* 322. Santa Fé; July. (426.)

†393. H. mollis, *Lam.; Torr. & Gray, l. c.* Near 110 Creek; Aug. (425.)

†394. H. Maximiliani, *Schrad., β.* asperrimus, *Engelm. & Gray, Pl. Lindh. no.* 261. Bottom land, south side of the ford of the Arkansas; Sept. (427.)

1. *p.* 48, proves, from specimens with good fruit raised in the Cambridge Botanic Garden from seeds communicated by Lindheimer, to have a squamellate pappus, and therefore to be a second species of Halea. The two species are thus characterized: —

1. Halea Ludoviciana (*Torr. & Gray*): foliis amplis ovatis crebre et argutissime dentatis, superioribus late connatis; tubo corollæ glabro; pappo e paleis ovalibus coriaceis circ. 20 latitudine achenii paulo brevioribus.

2. H. Texana: gracilis; foliis oblongis vel lanceolatis sinuato-pinnatifidis; tubo corollæ glanduloso; pappo e squamellis subulatis exiguis inæqualibus, majoribus vix dimidium latitudinis achenii æquantibus. — Dr. Gregg also gathered this species at Mier, on the right bank of the Rio Grande.

* Dr. Thomas C. Porter, of Pennsylvania, has furnished me with specimens of an ambiguous Helianthoid plant, gathered by himself on Rock Mountain, Georgia, which I am unable positively to determine for want of the fruit, but which I incline to refer to Rudbeckia, next to R. triloba, notwithstanding that the lower leaves are opposite and the disk-flowers are yellow. It may be provisionally characterized as follows: —

Rudbeckia? Porteri (sp. nov.): caule gracili hirsutulo apice paniculato; foliis membranaceis lanceolatis integerrimis utrinque acutis basi attenuata subsessilibus indistincte triplinerviis parce hispidis, superioribus alternis inferne setigero-ciliatis, inferioribus oppositis; pedunculis gracilibus 1–2-bracteatis monocephalis; squamis involucri biserialis exterioribus anguste linearibus foliaceis acutissimis laxis hispido-ciliatis disco longioribus, intimis paucis multo brevioribus oblongi-ovatis membranaceis glabris in cuspidem acuminatis paleis receptaculi conici consimilibus; ligulis aureis 7–9 obovati-oblongis involucrum duplo superantibus; corollis disci flavis profunde 5-lobis glabris; styli appendicibus filiformi-subulatis hispidis; ovariis calvis compressis marginibus parce hispidulis. — Capitula iisdem R. trilobæ minora.

†395. H. TRACHELIIFOLIUS, *Willd.; Torr. & Gray, l. c.* Creek bottom, 30 miles east of Council Grove; Aug.* (431.)

†396. HELIOMERIS MULTIFLORA, *Nutt. in Jour. Acad. Philad.* (*n. ser.*) 1. *p.* 171. Bottom land, seven miles east of Rock Creek, New Mexico; Aug. (432.) — The plant, which much resembles a Helianthus of the Microcephali group, or H. Nuttallii, is just in flower, and has no full-grown fruit. There is no trace of a pappus. — The same species was gathered by Dr. Wislizenus at Llanos, in the Sierra Madre, and a variety, or second species, occurs in the collection made by Fremont in his third expedition.† (This is probably the plant enumerated as Wulfia? in Dr. Torrey's appendix to Emory's Report.)

* Dr. Gregg's collection contains the well-marked H. ciliaris, *DC.*, gathered from near Berlandier's habitat, and an undescribed species, belonging apparently to the *Atrorubentes*, viz.: —

HELIANTHUS LACINIATUS (sp. nov.): caule erecto 2-pedali subglabro; ramis apice pubescentibus foliosis 1–3-cephalis; foliis plerisque alternis scabrido-pubescentibus ovato-lanceolatis vel oblongis triplinerviis laciniato-incisis dentatisve, superioribus basi lata sessilibus, inferioribus in petiolum marginatum attenuatis; involucri squamis ovato-lanceolatis acutis inappendiculatis dense ciliatis discum fuscum subæquantibus; ligulis circ. 20 brevibus; paleis receptaculi apice deltoideo pubescentibus; acheniis glabris biaristatis. — Valley of Nazas, Bolson de Mapimi, and west of San Lorenzo, Coahuila, *Dr. Gregg;* May. — Leaves 2 or 3 inches long; the middle cauline especially bearing two or three lanceolate lobes on each side (a quarter or half an inch long), the others with as many coarse teeth. Heads two thirds of an inch in diameter.

† To the same genus, which, as Mr. Nuttall remarks, is distinguished from Helianthus chiefly by the total absence of a pappus, I am obliged to refer a low, shrubby plant of Dr. Gregg's collection, viz.: —

HELIOMERIS TENUIFOLIA (sp. nov.): caule gracili 2–3-pedali frutescente ramosissimo diffuso foliosissimo; ramulis adscendentibus apice nudo pedunculiformi monocephalis; foliis alternis vel suboppositis supra glabratis subtus incanis tripartitis vel 1–2-pedato-partitis segmentis lobisque anguste linearibus margine revolutis, summis sæpe integerrimis; involucri hemisphærici squamis numerosis imbricatis e basi lanceolata lineari-appendiculatis canescentibus ligulis circ. 15 dimidio brevioribus; corollis disci flavis paleas naviculares obtusas superantibus; receptaculo subconico; acheniis cuneato-oblongis compresso-quadrangulatis glaberrimis calvis. — Dry valleys, at Rinconada, Saltillo, Mapimi, and Andabazo, Northern Mexico, *Dr. Gregg;* May, June. — Called "*Monacillo.*" Leaves crowded, usually fascicled in the axils, from one to two inches in length, cleft into three entire divisions, the middle one prolonged, or each division again 2–5-parted; the lobes and rachis only half a line wide. Involucre half an inch in diameter; the exterior scales longest, rather shorter than the convex disk. Rays neutral. Corolla of the disk-flowers 5-nerved; the tube more than half the length of the throat, puberulent, dilated at the base, where it fits over the apex of the achenium; the lobes short, nearly smooth. Appendages of the style oblong, tipped with a minutely hispid cone. — Some specimens are less hoary than others, but there seems to be no farther difference.

Dr. Gregg also collected Simsia auriculata, *DC.?* Likewise a second species, the achenia of which are almost awnless, viz.: —

SIMSIA SUBARISTATA (sp. nov.): humilis, strigoso-hispida; caulibus ramisve adscendentibus apice nudo pedunculiformi monocephalis; foliis hispido-incanis triangulari-ovatis serratis, superioribus hastato-trilobatis,

397. Coreopsis tinctoria, *Nutt.* East of Mora River, in low places; Aug. (441); and (442) between Coon Creek and Pawnee Fork, in shallow hollows in the

summis alternis, petiolo immarginato basi auriculato; involucri cano-villosi squamis æquilongis; ligulis 8 – 10 brevibus; acheniis glabris marginibus superne ciliolatis apice emarginata aristellis 1 vel 2 minimis donatis vel abortu vix bidentatis! — Bishop's Hill, near Monterey, *Dr. Gregg;* flowering in February. — The specimens, probably depauperate, are only a span high. The awns at most are not longer than half the breadth of the achenium, or the proper tube of the corolla; one of them is almost always abortive, and often both are reduced to a mere vestige. This species, therefore, invalidates the character of the genus Barrattia, *Gray & Engelm.*, which well accords with Simsia in habit; and which, although the absence of pappus would refer it to a different Candollean division of Heliantheæ, I fear cannot be maintained as a separate genus, after the discovery of the present species. At most, it differs from Simsia only as Coreopsis involucrata does from C. aristosa, and Actinomeris (Achæta) pauciflora from genuine Actinomeris. — The genus Geræa, *Torr. & Gray* (*Proceed. Amer. Acad.* 1. *p.* 48), must also be reduced to a section of Simsia.

✓ S. (Geræa; achenia, et aristæ palæoliformes inferne, villosissima) canescens: caule basi foliato simplici superne longe nudo 1 – 3-cephalo; foliis incano-hirsutissimis alternis vel imis subrosulatis obovatis rhombeisve sæpius integerrimis basi trinervatis subsessilibus, summis ad bracteas parvas reductis, involucri triserialis squamis villosissimis; ligulis maximis cuneato-obovatis apice subtrilobis tubo piloso gracili discum æquante stipitatis; acheniis oblongo-cuneiformibus pilis argenteis præsertim ad margines longissimis villosissimis; aristis lineari-subulatis corollam subæquantibus. — Interior of California, *Fremont, Coulter.*

From Texas Mr. Wright sends an Actinomeris with nearly awnless achenia, but which has not decurrent leaves as in Nuttall's A. (Achæta) pauciflora, and connects that anomalous species with the section Apteron.

✓ Actinomeris Wrightii (sp. nov.): caulibus gracilibus undique foliosis apice subcorymbosis; ramis paucis superne nudiusculis monocephalis; foliis oppositis summisve alternis ovatis grosse serratis triplinerviis crassis utrinque scaberrimis basi cuneatis vel abrupte angustatis sessilibus haud decurrentibus plerisque internodiis duplo longioribus; involucri hemisphærici squamis ovalibus obtusissimis 3 – 4-seriatim imbricatis disco fructifero convexo brevioribus; receptaculo convexo; ligulis 9 – 12 elongatis; acheniis oblongis lato-alatis apice emarginato nudis, aristis rudimentariis dentiformibus alæ adnatis. — Mountains near Austin, Texas; Sept. *Mr. Wright.* — Stems many from the same root, two or three feet high. Leaves from 2 to 4 inches long; those of the short flowering branches small, obtuse and alternate. Heads larger than in A. helianthoides. Rays golden-yellow, an inch long. Achenia 4 lines in length.

Among the novelties gathered in the mountains about Cosiquiriachi by Dr. Wislizenus, a striking Helianthoid plant occurs, which I refer to Tithonia, viz.: —

✓ Tithonia decurrens (sp. nov.): pube molli subdecidua undique cano-villosa; caule robusto ad apicem usque foliosissimo; foliis ovato-lanceolatis acutis subintegerrimis penninerviis basi decurrentibus supra demum glabratis scabris; pedunculo cylindrico capitulo subgloboso breviore; involucri biserialis squamis ovato-oblongis appressis apice brevi foliaceo patentibus discum vix æquantibus; paleis receptaculi convexi rigidis apice truncato bimucronatis; acheniis disci sericeis 2-aristatis; aristis subulatis squamellisque crassis persistentibus. — On the Bufa; common on the mountains around Cosiquiriachi, in the State of Chihuahua, *Dr. Wislizenus;* Oct., in fruit. — Herb 2 or 3 feet high, stout. Leaves 4 to 8 inches long, sessile and strongly decurrent, not triplinerved, but the primary veins confluent into an intramarginal vein, hoary beneath with a villous, above with a short and soft, pubescence, which is readily detached by rubbing. Heads termi-

prairies, said to have been made by the buffaloes in wallowing. — The rays are brown only at the base.

†398. C. INVOLUCRATA, *Nutt. in Trans. Am. Phil. Soc. (n. ser.)* 7. *p.* 360. Hollows in the prairies near 110 Creek; Sept. (444). — The achenia are obovate, repand-truncate at the apex, scarcely 2-toothed, entirely awnless; the margins hispid.

†399. COSMOS BIPINNATUS, *Cav. Ic.* 1. *p.* 9. *t.* 14. Woodland, ten miles west of Las Vegas; Aug. (447.) — Rays smaller than in Mexican specimens; the achenia only two-awned. (No. 448 is an autumnal specimen of the same, in fruit; from Santa Fé.)

400. COSMIDIUM GRACILE, *Torr. & Gray, Fl.* 2. *p.* 350. Santa Fé, at the foot of irrigating ditches; and on the Rio del Norte; May to Sept. (445.) (Also gathered by Fremont on the Upper Platte and Arkansas, and by Wislizenus on the Arkansas, and again at Albuquerque.) — The specimens are all rayless, like that of Dr. James. The corolla is yellow, but turns brownish in fading. The mature achenia are narrowly linear, straight or nearly so, 4 lines long, more or less tuberculate; their base cohering with that of the chaff, with which they fall away; the abrupt apex bearing two short and diverging retrorsely barbed *persistent* awns. — There is a third species, with simple leaves, in Dr. Gregg's collection.*

401. BIDENS TENUISECTA (sp. nov.): annua, glabriuscula, caule ramoso tereti adscendente; ramis striato-angulatis apice nudo 1–3-cephalis; foliis (oppositis alternisve) bipinnati partitis vel biternatisectis, segmentis linearibus integerrimis seu 2–3-lobatis rachi paulo latioribus; squamis involucri hirsuti linearibus; ligulis 5–8 inconspicuis discum vix æquantibus; acheniis attenuato-linearibus glabris subtetragonis striatis breviter 2-aristatis. — Margins of Poñi Creek (between Bent's Fort and Santa Fé); Oct. (449.) — Plant one or two feet high, with a very smooth stem. Segments of the leaves seldom over a line in width, and, except the lowest, little wider than their rachis. Heads rather larger than those of B. bipinnata, and with a greater number of disk-flowers. The naked peduncles in the wild specimens are 5 or 6 inches long, bearing a single head; in

nating the stem or the few short branches, on thick peduncles of only half an inch in length. Involucre an inch in diameter. Sterile ray-achenia nearly smooth, with a short pappus: fertile achenia 3 lines long; the stout awns about the same length, three or four times the length of the rigid lacerate-denticulate squamellæ. Although different in aspect from the described species, it agrees in floral characters with Tithonia.

* COSMIDIUM SIMPLICIFOLIUM (sp. nov.): caulibus e radice perenni simplicibus 1–3-cephalis; foliis rigidiusculis filiformi-linearibus integerrimis; squamis involucri exterioris ovatis parvis, interioris ad medium connatis ligulis obovato-cuneatis apice trilobis multo brevioribus; acheniis valde immaturis dentibus 2 squamæformibus retrorsum hispidis coronatis (maturis ignotis). — High and dry land, battle-field near Buena Vista, Coahuila, *Dr. Gregg;* May. — Leaves two inches long; the radical ones slightly dilated upwards. Ligules half an inch long.

the plant raised from seed in the Cambridge Botanic Garden the flowering branches are more leafy, and bear three or four heads on shorter peduncles. Achenia half an inch long. The species should stand next to B. bipinnata.

†402. B. FRONDOSA, *Linn.* Ford of the Arkansas, &c.; Sept. (443.)

†402 bis. B. CONNATA, *Muhl.* Low plains near Council Grove; Sept. (439, 435.)

403. XIMINESIA ENCELIOIDES, *Cav.*, δ. CANA, *DC.* Waste grounds, about Santa Fé; May to Sept. (421.) Also in the Raton Mountains, along the Rio de los Animos. — Wings of the achenia opaque and thickened. The plant raised from these seeds in the Botanic Garden, Cambridge, is much less canescent.

✓ †404. SANVITALIA ABERTI (sp. nov.): caule erectiusculo ramoso; foliis lanceolatis trinervatis hispido-scabris in petiolum attenuatis; capitulis primariis pedunculatis nudis; involucro disco (viridi-flavo) fructifero brevioribus; ligulis ovatis longitudine achenii aristas duplo excedentibus; acheniis disci fere conformibus compresso-quadrangulatis tuberculatis exalatis paucisve suberoso-subalatis apice emarginatis calvis aut minime uniaristulatis. — Woodlands, between Santa Fé and Pecos; Aug. (538.) — The specimens have barely produced the primary heads (which are much smaller than in S. procumbens). The fruit, &c., is here described from a mature specimen in Dr. Torrey's herbarium, gathered by Lieut. Abert, between Bent's Fort and Santa Fé. The plant is a span high, and bears all its terminal heads on naked peduncles half an inch long; and the disk is greenish-yellow, not purple nor blackish. Ligules a little more than a line long.*

✓ 405. HETEROSPERMUM TAGETINUM (sp. nov.): caule bifariam hirsutulo; foliis pinnato-3–7-partitis more Tagetis pellucido-glandulosis, segmentis linearibus integerrimis; squamis involucri exterioris 3 linearibus capitulum superantibus; acheniis radii ala angusta crassa arcte inflexa cinctis, disci exterioribus calvis centralibus rostratis biaristatis. — Woodlands, twelve miles west of Las Vegas, New Mexico; Aug. (534.) — Annual, a foot high; the foliage, involucre, &c., much as in H. pinnatum; but the segments of the leaves are entire, and pellucid-punctate with abundance of coarse glands, as in Tagetes, those near the margins oblong, the others mostly globular and smaller. The awnless achenia are obovate and very glabrous; the three or four central are flat, and taper into an upwardly hispid-scabrous beak, which bears a pair of retrorsely aculeolate, deciduous awns. In H. pinnatum, the original species of the genus (which in these respects is not well characterized by De Candolle), all the disk-achenia are 2-awned and more or less

* Oligogyne Tampicana, *DC.*, occurs abundantly in the collections made by Dr. Gregg and others in Tamaulipas, at Monterey, &c. Only some of the terminal heads are long-pedunculate: the later ones are frequently almost sessile.

scabrous-hispid; the outermost obovate and obtuse; the next series somewhat produced at the apex; and the innermost linear and elongated into a rough beak.

406. Flaveria angustifolia, *Pers.; DC.! Prodr.* 5. *p.* 635. Low prairie, Middle Spring of the Cimarron; Aug.* (536.)

†407. Dysodia chrysanthemoides, *Lagasca; Torr. & Gray, Fl.* 2. *p.* 362. Santa Fé Creek; June. (526.) — D. tagetoides, *Torr. & Gray, l. c.*, with an allied new Texan species (both of which exhale a pleasant, somewhat anisate odor when bruised) I incline to append to Hymenatherum, notwithstanding some difference in habit. After separating also the doubtful section Aciphyllæa, the genus Dysodia will be left much more homogeneous; the paleæ of the pappus in all pinnato-pilosus v. plumosus. The result of the study of some interesting North Mexican materials is subjoined.†

* Besides F. Contrayerba, two undescribed species occur in North Mexican collections, viz.: —

Flaveria longifolia (sp. nov.): erecta, stricta; foliis carnosis angusto-linearibus prælongis sursum attenuatis acutissimis sæpe falcatis uninerviis spinuloso-denticulatis, superioribus basi lata connato-sessilibus, inferioribus inferne angustatis; corymbo terminali nudo densiusculo; capitulis discoideis 12–15-floris. — Near Cienega Grande, Coahuila, *Dr. Gregg;* May. — The specimens, a foot long, do not show the base of the strict stem. Cauline leaves 4 or 5 inches long, about 2 lines wide near the base, tapering to the apex, nearly all of them denticulate with from 3 to 6 salient mucroniform teeth on each margin. Heads nearly 2 lines long, in a strict and naked compound corymb.

F. chlorælolia (sp. nov.): glauca; caule humili (6–10-pollicari) e radice perenni? adsurgentibus simplicibus corymbo nudo simplici fastigiato terminatis; foliis oblongis connato-perfoliatis integerrimis uninerviis subacutis; capitulis circ. 12-floris discoideis. — Pelayo, northwest of Mapimi, in the State of Chihuahua, *Dr. Wislizenus;* May. And winter vestiges of what is doubtless the same species, though the leaves and flowers have fallen, occur in Dr. Gregg's collection, from "a spring northwest of Mapimi." — The leaves of this remarkable species resemble those of Chlora perfoliata. They are not at all narrowed below, but connate-perfoliate from a broad base, thickish, scarcely an inch long, the upper smaller and inclined to be lanceolate and acute. Heads nearly as large as in the preceding species.

† HYMENATHERUM, *Cass., DC.* (excl. § 2), non *Less.*

Pappus e paleis 10 indivisis vel superne trifidis, aut omnibus aut alternis 1–3-aristatis; aristis scabris. Squamæ involucri 1–2-seriales, in cupulam pl. m. concretæ.

§ 1. Paleæ pappi rigidæ, conformes, alternæ paulo breviores, omnes aristatæ vel acutatæ. Involucrum bracteatum, squamis fere ad apicem concretis. — Herbæ biennes? erectæ, rigidæ, glabræ; foliis linearibus, pinnatifido-laciniatis dentibus subulatis, vel integris; pedunculis subcorymbosis nudiusculis.

H. tagetoides: caule pedali apice corymboso; foliis elongatis subpinnatifidis, nempe, laciniis elongato-subulatis utrinque 6–10 instructis, ramealibus integrioribus; bracteis utrinque pauci-setigeris involucro cylindracei-campanulato (sicco cartilagineo) subbrevioribus; ligulis elongatis; receptaculo convexo alveolato; pappo achenio 4–5-gono breviore tubum corollæ disci non superante, paleis coriaceis lanceolato-subulatis subtrifidis vel integriusculis 1–3-cuspidatis seu apice subaristatis. Dysodia tagetoides, *Torr. & Gray, Fl.* 2. *p.*

408. LOWELLIA, *Nov. Gen.* Tagetinearum.

Capitulum multiflorum, heterogamum; floribus radii ligulatis fœmineis, disci tubulosis hermaphroditis. Involucrum campanulatum, ebracteatum, gamophyllum; squamis subbiserialibus lanceolatis inferne carinatis ultra medium coalitis. Receptaculum convexum, nudum. Ligulæ circiter 12, ellipticæ, exsertæ (deciduæ). Corollæ disci infundibuliformes, 5-dentatæ. Styli rami fl. hermaph. apice capitellato-truncati puberuli. Achenia elongata, teretia, multistriata, pappo simplici brevissimo, e paleis 6–8 liberis æqualibus

361. In moist places, Western Louisiana, *Leavenworth;* and Texas, *Drummond, Lindheimer, Wright;* flowering in August and September. — Manifestly allied to the next, which has strictly the characters of Hymenatherum, although of different habit from the original species.

H. Wrightii (sp. nov.): caule dodrantali a basi ramoso; ramis adsurgentibus apice nudis monocephalis; foliis anguste linearibus integris aut plerisque versus basin longe attenuatam utrinque dentibus laciniisve spinulosis 1–3 instructis; bracteis subulatis appressis involucro turbinato chartaceo multum brevioribus; ligulis breviusculis; receptaculo plano nudo; pappo achenio gracili sublongiore, e paleis angustis subæqualibus trifidis omnibus 3-aristatis, arista media corollam fl. disci paulo superante lateralibus duplo longiore. — In dry Post-Oak woods between the Rio Colorado and Rio Guadeloupe, Texas, *Mr. Charles Wright.* Also on the Piedernales, *Lindheimer.* Flowering from April to June. — Heads smaller than in the preceding; the scales of the involucre perfectly united in one series. Leaves one or two inches long, scarcely a line wide.

H. Neæi, *DC.*, appears to belong to this section. H.? Kunthii, *DC.* = Lasthenia obtusifolia, β. *DC.* and Rancagua Bridgesii, *Pœpp. & Endl.*, according to *Hook. & Arn. in Jour. Bot.* 3. *p.* 320.

§ 2. Paleæ pappi membranaceæ vel chartaceæ, 5 alternæ plerumque breviores et truncatæ. Involucrum fere ebracteatum. — Herbæ humillimæ, ramosissimæ, annuæ, vel basi suffrutescentes; capitulis solitariis.

* *Glabræ vel cinereæ; folia rigida pinnato-partita, segmentis paucis acerosis vel filiformibus: pedunculi gracillimi nudi.*

H. tenuifolium, *Cass. Bull. Philom.* 1817 & 1818, & *Dict. Sci. Nat.* 22. *p.* 314, the original species of the genus, is still obscure. It was described from a specimen in the herbarium of Jussieu, "où il est dit avec doute qu'elle vient du Chili." It is said to be a small, diffuse, annual plant, with angled stems, opposite and filiform pinnate leaves, and solitary heads terminating the branches. In the generic character, the scales of the involucre are said to be united nearly to the summit; the pappus of 10 membranaceous scales, which are cleft above into two or three barbellulate setæ. Probably it should be placed in the foregoing section. Hooker and Arnott (*in Jour. Bot.* 3. *p.* 320) suspect it may be their H. Candolleanum, from Mendoza and North Patagonia. De Candolle doubtfully refers it to

H. tenuilobum, *DC. Prodr.* 5. *p.* 642. This is described from a specimen of Berlandier, gathered in the vicinity of Bexar, Texas, and from one in the collection of Neé, the habitat of which is unknown. It is said closely to resemble H. Berlandieri, except that the ten paleæ of the pappus are all (alike?) 3-cleft at the apex, with the middle lobe setiform, the lateral ones short and nearly membranaceous. — I have seen no specimens which agree with this as to the 10-awned pappus. But I possess a Texan specimen, communicated by Mr. Wright (who informs me that it is not of uncommon occurrence from the Nueces to the Rio Grande),

oblongis apice truncato-erosis enerviis, coronata. — Herba annua, glabra, grosse glandulosa, Dysodiæ chrysanthemoidis facie, sed foliis plerisque alternis atque ligulis aureis conspicuis. — Genus inter Dysodiam et Tagetem referendum, ab utrisque pappo parvo simpliciter et æqualiter squamellato plane diversum, dicavi in memoriam Hon. Johannis Lowell, qui non solum res georgicas sed etiam herbarias in Nova Anglia magnopere promovebat, in honoremque filii Johannis-Amory Lowell, de botanice bene meriti, itineris Fendleriani fautoris.

which well accords with the description, except that only from three to five of the paleæ of the pappus are awned, and which I consider as only a variety of the species referred below to H. pentachætum.

H. Berlandieri, *DC. l. c.* If Berlandier's plant, gathered between Santander and Vittoria, Mexico, is the same as Hartweg's no. 129, from Aguas Calientes in the south of Zacatecas (which alone I have seen), the species is well distinguished from the next by the more upright growth, the longer lobes of the leaves (the terminal an inch or more in length), and the smaller, fewer-flowered involucre, which is hardly two lines long, cylindraceous, and with the strictly uniseriate scales united to the top. The pappus has five of the scales much shorter than the others, oblong, truncate or very obtuse, and unawned; the five alternate ones oblong-lanceolate, bearing two short, more or less cuspidate or setigerous teeth at the apex, and between them produced into a slender and scabrous awn, a little shorter than the corolla.

H. pentachætum, *DC. l. c.* Of this it is said: "Facile cum H. Berlandieri et tenuilobo prima fronte confundendum, sed pappo 5- nec 10-setoso distinctum." The plant was gathered at Monterey, Mexico, by Berlandier. From the same locality (Monterey, near the Bishop's palace, &c.), as well as from the "highlands around Saltillo and Buena Vista," Dr. Gregg abundantly collected specimens which well accord with the character of this species, except that they all exhibit the five shorter and erosely truncate paleæ of the pappus, just as in the preceding. A specimen gathered at Monterey by Dr. Edwards exhibits the same characters; as also do those of Dr. Wislizenus, gathered farther west, between San Juan and Vequeria. I cannot but conclude that these shorter paleæ of the pappus were overlooked by De Candolle. The rigid, Heath-like foliage is densely crowded on the diffuse and tufted branches, and cinereous-pubescent: the naked peduncles are 2 inches long, and bear a few minute and scattered setaceous bracts: the campanulate or broadly turbinate involucre is three lines long, cinereous-puberulent; with the scales evidently biseriate, and distinct or separable, the exterior especially, for a fourth part or nearly half their length. The five awns of the pappus are nearly as long as the disk-corolla. — A Texan specimen, mentioned above, from Eagle Pass, on the Rio Grande, has one or two of the larger paleæ unawned and pointless, and has merely glabrous leaves: but I see no other distinction.

* * *Floccoso-lanatæ: folia integra spathulata: pedunculi fere nulli.*

H. gnaphalodes (sp. nov.): nana, undique albo-lanatissima; caulibus e radice annua? ramosis depressis proliferis; foliis plerisque alternis spathulatis integerrimis vel apice rotundato subdentatis confertis ad innovationes imbricatis; capitulis brevissime pedunculatis vel intra folia sessilibus; involucri 1 – 3-bracteati squamis uniseriatis connatis; ligulis 10 – 13 ovalibus exsertis; pappi paleis 5 majoribus lanceolatis alternas eroso-truncatas triplo superantibus apice in subulas 2 membranaceas et aristam mediam corollam disci subæquantem trifidis. — On Bishop's Hill, Monterey, February, *Dr. Gregg.* Called "*Lipillana.*" — Plant with much the aspect of Filaginopsis, *Torr. & Gray*, or of Diaperia, *Nutt.*; the rigid, but apparently annual, tufted stems

✓ †408. L. AUREA. Between Cold Spring and Upper Spring, west of Cimarron Creek; Aug. (436.) — Stem a span or more in height, branching, leafy, very much resembling Dysodia chrysanthemoides, except in the ample and conspicuously exserted rays. Lower leaves mostly opposite, the others alternate, all pinnately parted or pectinate; the segments about 11, filiform-linear, entire, not broader than the rachis; the glands large in proportion, orange-colored. Heads solitary on naked peduncles, terminating the co-

only two inches high, terminated by sessile and equally woolly heads about a third of an inch long. Leaves 3 or 4 lines long, one or two lines broad near the summit. On separating the thick covering of white wool, a few large yellowish glands, like those of the tribe, may be seen on the leaves. From the involucre it separates more readily, and shows from 4 to 6 such globular glands arranged in two rows along the apex of each scale between as many pinnate veinlets: the glands appear to be superficial. Receptacle convex, naked. Ligules yellow, but turning greenish, 2 lines long. Pappus, style, &c., nearly as in the foregoing species, of which, notwithstanding its remarkable habit, it is certainly a congener.

ACIPHYLLÆA, *DC.* (sub Dysodia).

Capitulum multiflorum, heterogamum; floribus radii 5–8, ligulatis, fœmineis, disci tubulosis hermaphroditis. Involucri squamæ uniseriales, in cupulam oblongo-cylindricam apice breviter 8–14-dentatam concretæ. Receptaculum planum, minute alveolatum. Styli rami fl. disci cono brevissimo hispidulo capitellati. Achenia gracilia, teretia, multistriata. Pappus uniserialis, e squamellis circ. 20 conformibus (alternisve paulo minoribus), in aristas setasve scabras inæquales 3–5 palmato-partitis, constans. — Suffruticulus ericoideus, ramosissimus, diffusus, vix semipedalis, fere glaber; foliis oppositis alternisve confertis, sæpe in axillis fasciculatis, acerosis, integerrimis, grosse glandulosis; capitulis (3–4 lin. longis) apice ramulorum solitariis sessilibus, foliis supremis quasi calyculatis; floribus flavis.

✓ A. ACEROSA. — Dysodia (§ ? Aciphyllæa) acerosa, *DC. Prodr.* 5. *p.* 641. Mexico, in the State of San Luis Potosi, *Berlandier*, ex *DC.* Near Saltillo and Parras, *Dr. Gregg.* Donana, north of El Paso del Norte, *Dr. Wislizenus.* — Called "*Yerba de San Nicolas*" at Saltillo: appears to be abundant in that part of Mexico. There are several forms in the collections, varying in the size and fasciculation of the leaves (the longer of which are half an inch long), &c.; but apparently all belong to one species, which I suppose to be that of De Candolle also, although I have not observed the involucre to be fewer than 10-toothed, nor are the achenia glabrous (though they appear so, except under the lens), but sparsely hairy. Perhaps there is more than one species. The whole aspect of the plant is very unlike Dysodia; from which the simpler pappus may serve technically to distinguish it; while from Hymenatherum it is distinguished by the numerous and more than 3-aristate paleæ of the pappus.

THYMOPHYLLA, *Lagasca.*

Capitulum homogamum. Pappus e "paleis 5 truncatis brevibus," vel in coronam fere integerrimam concretis. Cæt. Hymenatheri. — Suffruticuli multicaules, ramosissimi, albo-lanosi; foliis confertis setaceis integerrimis, vel infimis pinnato-partitis; pedunculis filiformibus nudis monocephalis.

✓ T. SETIFOLIA, *Lag. Nov. Gen. Elench. Hort. Madr. p.* 25. Ex char. *Lagasc.:* Pappus pentaphyllus, paleis truncatis brevibus: folia opposita subsetacea, tomentosa, vix sesquilineam longa: pedunculi terminali,

rymbose branches, not calyculate. Involucre composed of 14 or 15 oblong-lanceolate scales which are concreted into a campanulate cup but pretty distinctly occupy two series, the exterior with their margins partly free, each bearing about four large and round glands. Rays 14 or 15, nearly 4 lines long, golden-yellow, as well as the numerous disk-flowers. Pappus scarcely half the length of the proper tube of the corolla, one sixth of the length of the nearly glabrous achenia; the paleæ all equal and similar, entirely awnless and nerveless.

villosuli, 2-pollicares: corolla atropurpurea, ut in sicco apparet. In Mexico. — This plant remains unknown to botanists, unless the following, which is certainly congeneric, should prove to be the same species.

T. Greggii (sp. nov.): spithamæa, basi multicaule suffrutescens, lana alba floccosa undique tomentissima; foliis oppositis alternisve, inferioribus ($\frac{1}{2}$–$\frac{2}{3}$ unc. longis) pinnato-3–5-partitis lobis setaceis, superioribus integris setaceis, ramealibus brevioribus (2–4 lin. longis) imbricatis vel fasciculatis; pedunculis erectis (2–4 unc. longis) demum glabratis, minutissime bracteatis; involucro circ. 15-dentato; acheniis gracilibus multistriatis glaberrimis pappo calyciformi margine subintegro iisdem corollisque flavis quadruplo breviore coronatis. — Dry valley and highlands near Buena Vista, Coahuila, *Dr. Gregg;* March. Called "*Contra-yerba.*" Except as to the concreted pappus, and the pinnated leaves, which do not appear on the flowering branches and might be overlooked, this plant nearly agrees with the brief characters of T. setifolia, given by Lagasca. The lower leaves are much less woolly when old; and under this covering scattered glands, like those of other Tagetineæ, may be discerned. The size of the heads in Lagasca's plant is not mentioned. In this they are only two lines long. The minutely 1–2-bracteate involucre also loses its woolly covering, and shows one or two large glands near the apex of each component scale. The receptacle is flat, and minutely alveolate or naked.

CLOMENOCOMA, *Cass.*

A solitary specimen of Clomenocoma aurantia, *Cass.*, brought from Mexico by Dr. Halstead ("Plan del Rio, April 16th") and which I have examined in *Herb. Torr.*, furnishes the following particulars to the generic character: — Ligulæ in tubulum longum gracilem sublatæ. Corollæ disci tubo proprio brevissimo, fauce cylindrica prælonga, lobis linearibus glabris. Styli rami fl. hermaph. elongati, lineis stigmaticis conspicuis percursi, cono subulato acutissimo hispido terminati. Paleæ pappi 10, in setam mediam longissimam simplicem vel bisetuligeram, squamellasque 2 iterum 2–3-fidas et in setas desinentes, profunde trifidæ. — Folia eglandulosa. Involucrum pluriseriatim imbricatum.

TAGETES, *Tourn.*

The pappus in this genus is remarkably various. The subjoined species, which has the aspect of T. micrantha, *Cav.*, is peculiar on account of the complete union of the paleæ and single awn into a tube which is longer than the achenium: —

T. Wislizeni (sp. nov.): annua, exigua, glaberrima; foliis alternis vel infimis oppositis interrupte pinnato-partitis, segmentis 7–10 setuloso-mucronatis, minoribus subulatis, majoribus linearibus vel oblongis inciso-3–7-dentatis; ramis fastigiatis in pedunculum nudum filiformem iisdem multo longiorem monocephalum desinentibus; involucro fusiformi apice constricto breviter 4-dentato circ. 8-floro; ligulis 2–3 brevissimis rotundatis vix exsertis; pappi paleis ut videtur 5 in tubum cylindricum achenio longiorem corollam prælongam sub-

409. RIDDELLIA TAGETINA, *Nutt.! in Trans. Amer. Phil. Soc. (n. ser.) 7. p. 371; Torr. & Gray, Fl. 2. p. 362, & Suppl. Compos. ined.; Torr. in Emory's Report, t. 5.* Valley of Santa Fé Creek, at the foot of hills, near irrigating ditches; June, July: also between San Miguel and Santa Fé, in woodland; Oct. (461.) — These are exceedingly fine specimens of a rare and interesting plant, which, from its profuse corymbose heads with their large, bright-yellow, papery-persistent rays, would be very ornamental in cultivation. Col. Emory likewise gathered specimens in New Mexico; and Dr. Wis-

claudentem apice uni- vel in radio bi-aristatum arcte coalitis, aristis barbellatis. — On high mountains around Cosiquiriachi, in the Sierra Madre west of Chihuahua, October, *Dr. Wislizenus.* — The stems of this little plant are only an inch and a half high; while the peduncles are nearly the same length. The purplish involucres are half an inch long; the filiform tube of the (yellow) ligules nearly as long. Receptacle convex, alveolate. Tube of the pappus unequally 3–4-toothed at the apex, and produced into a stout rough-barbellate awn much longer than the disk-corolla, or in the ray often with two such awns.

CHRYSACTINIA, *Nov. Gen. inter* Tagetearum et Porophyllearum?

Capitulum multiflorum, heterogamum; fl. radii 9–12, ligulatis, fœmineis, disci tubulosis hermaphroditis. Involucrum uniseriale disco brevius; squamis 9–12, æqualibus, distinctis, oblongo-linearibus, dorso carinatis, supra medium uniglandulosis. Receptaculum parvum, hemisphæricum, corneo-alveolatum. Ligulæ elongatæ, oblongæ. Corollæ disci tubulosæ 5-dentatæ, dentibus ad margines incrassato-puberulis. Styli fl. hermaph. rami elongati, anguste lineares, planiusculi, cono brevi obtuso hispidulo terminati, et dorso infra apicem minutim hirtelli. Achenia elongata, linearia, erostria, multistriata, hispidula, involucro fructifero laxo æquilonga, callo basilari manifesto. Pappus pilosus simplex; setis fere uniserialibus, denticulato-scabris, achenio longioribus. — Fruticulus Mexicanus, ramosissimus, glaber; ramis strictis conferte foliosis; ramulis floridis fastigiatis in pedunculis nudis parce setaceo-bracteatis monocephalis desinentibus; foliis alternis imisve sæpe oppositis, lineari-subulatis, mucrone apiculatis, crassis, supra ad costam sulcatis, utrinque serie glandularum grossarum rotundarum notatis; floribus aureis, ligulis disco duplo longioribus conspicuis. (Chrysactinium § Andromachiæ, *Kunth* = Liabium, *Adans.*)

C. MEXICANA. — Dry valley west of Saltillo, April; and on high grounds near Buena Vista, May, *Dr. Gregg.* Also at "Ojo del Agua," near the city of Mexico? *Dr. Halstead* (in herb. Torr.). Shrub one or two feet high, Heath-like; the rigid stems roughened with the scars of fallen leaves. The leaves are light-green, crowded, apparently persistent for two years, from one fourth to two thirds of an inch in length, flat or more or less involute, very conspicuously pustulate, especially underneath, with a row of large and impressed brownish glands. Peduncles one or two inches long. Heads an inch broad, including the elongated spreading rays. Involucre only two or three lines long; the single gland on each scale oval or oblong. Pappus longer than the achenium, somewhat tawny or livid. — This plant apparently is by no means uncommon; but I find it nowhere described. The characters of the style, in which the stigmatic lines extend through the whole length of the flattish branches quite into the short flattened-conical tip, as well as the principally alternate leaves, exclude the genus from the Eupectideæ, as do the glands of the leaves from the division Liabeæ. It must therefore be referred to Tagetineæ, where it combines the characters of the two divisions, having the rays and the style of the Tageteæ, with nearly the pappus, involucre, and foliage of Porophyllum. The name is given in allusion to the (golden-yellow) rays, which distinguish the plant from Porophyllum.

lizenus found it very common along the Rio Grande nearly as far south as El Paso. Before this, the genus was known only from scanty specimens in Dr. James's collection, made in Long's expedition, doubtless from the Upper Canadian, but the locality was not recorded. In establishing the genus, Mr. Nuttall omitted to state that his plant was derived from the collection of Dr. James, through Dr. Torrey, whose remaining specimen being mislaid at the time and forgotten, the character of the genus in the *Flora of North America* was drawn up from Nuttall's published description alone.* This requires emendation as to the involucre, which is by no means gamophyllous. A second species with some remarkable peculiarities having now been detected, the full characters of the genus, and of the two species, are here subjoined.† The aspect is rather that of Zinnia than of

* Dr. Torrey's remark in respect to the discovery of the plant, in *Emory's Report*, *p.* 144, is founded on the same misapprehension as to the discoverer.

† RIDDELLIA, *Nutt.* (char. augm.)

Capitulum pluriflorum, heterogamum; fl. radii 3, ligulatis, fœmineis, persistentibus; disci 6 – 9 tubulosis, hermaphroditis. Involucrum cylindricum, pilis longis intertextis lanatum, e squamis 8 – 10 oblongo-linearibus coriaceis rigidis conniventibus (sed discretis) uniserialibus, cum 3 – 6 interioribus anguste linearibus scariosis æquilongis, constans. Receptaculum planum, subalveolatum. Ligulæ ratione capituli maximæ, e basi breviter tubulosæ abrupte dilatatæ (latiores quam longæ), planæ, apice 3 – 4-lobæ, post anthesin ampliatæ et chartaceæ, persistentes. Corollæ disci tubulosæ, 5-dentati, dentibus glandulosis. Styli fl. hermaph. rami apice capitellato-truncati minutim barbati. Achenia lineari-oblonga, 4 – 5-angulata, multistriata; radii leviter obcompressa. Pappus simplex, achenio brevior, 4 – 6-paleaceus; squamellis oblongis vel lanceolatis, hyalino-membranaceis, enerviis, muticis, subæqualibus, aut integris nudis, aut lacerato-piligeris! — Herbæ humiles, floccoso-lanatæ, ut videtur annuæ, subaromaticæ, caulibus fastigiato-ramosis foliosis; foliis alternis oblanceolatis integerrimis, infimis et radicalibus spathulatis sæpe paucidentatis vel subpinnatifidis; glandulis immersis vix ullis; capitulis ad apicem ramorum corymbosis; floribus aureis, ligulis post anthesin pallidioribus (sulphureis).

1. R. TAGETINA (*Nutt. l. c.*): ramis fastigiato-corymbosis; foliis patentibus; pedunculis capitulis longioribus; acheniis glabris; pappi paleis obtusis integerrimis. — Plant 7 to 15 inches high, less woolly with age; the erect-spreading branches usually fastigiate. Peduncles elongating after anthesis, becoming from half an inch to an inch long. Rays from a quarter to over a third of an inch in length and breadth. Pappus almost half the length of the disk-corolla.

2. R. ARACHNOIDEA (sp. nov.): caule parce ramoso foliisque dense lanatis strictiusculis; corymbo conferto; pedunculis involucro brevioribus; acheniis pilis longissimis arachnoideo-villosis; pappi paleis diaphanis superne in pilos arachnoideos prælongos lacerato-diliquescentibus. — Dry soil, around Buena Vista and Saltillo, *Dr. Gregg*, *Dr. Wislizenus:* also near Monterey, *Dr. Edwards.* — Plant 6 or 8 inches high, with much the aspect of the preceding; but the leaves are mostly narrower and the heads smaller and more crowded. The rays, which are usually 4-lobed, in the dried specimens are orange-colored even when old (instead of sulphur-yellow) as well as during anthesis. The delicate, cobwebby hairs which cover the young achenium are much like those which densely clothe the involucre: they exceed the achenium itself in length, mingling with those into which the thin, lanceolate pappus-scales are lacerate-dissected. In all other particulars this remarkable species well accords with the former.

Tagetes; the pellucid glands are wanting or indistinct; and the styles exactly correspond with those of many Heleniæ; in which subtribe, next to Bahia, I should therefore prefer to place the genus.

†410. GAILLARDIA LANCEOLATA, *Michx.* On the Arkansas near Walnut Creek; Sept. (453.)

411. G. PULCHELLA, *Foug.; Torr. & Gray, Fl. 2. p.* 366. On the Cimarron and Pawnee Fork of the Arkansas; Aug., Sept. (454.)

†412. G. PINNATIFIDA, *Torr. in Ann. Lyc. N. Y. 2. p.* 214; *Torr. & Gray, l. c.* Foot of dry, stony hills, Santa Fé; June, July. (450.) — A dwarf species, readily distinguished by its pinnately-parted leaves, with the divisions and rachis narrowly linear. The root is probably only biennial; the naked peduncles as long as the stems; and the rays, in Fendler's specimens, entirely yellow. It is also in Col. Emory's collection, from New Mexico, and in Dr. Gregg's from Chihuahua.

†413. G. PINNATIFIDA, *Torr.:* var. minus canescens; involucri squamis ligulas (flavas) æquantibus vel superantibus. Seven miles east of Rock Creek, New Mexico: Aug. (451.) — Also gathered in Fremont's third expedition, probably towards the sources of the Arkansas. Specimens intermediate between this and the preceding number were gathered by Dr. Gregg at San Pablo, below Chihuahua. — The naked peduncles are from 6 to 10 inches in length, usually much longer than the leafy stems; so that the plant approaches Agassizia, *Gray & Engelm. (in Proceed. Amer. Acad. p.* 48) in aspect; but the appendages of the style, the rays, &c., are as in the rest of the genus.* Cultivated from seeds gathered by Fendler, it proves to be a very ornamental plant.

†414. G. PINNATIFIDA, *Torr.:* var. foliis imis sinuato-pinnatifidis. Otherwise as in no. 451. Rio del Norte, at the foot of hills; May. (452.)

415. PALAFOXIA (PALINODIA†) HOOKERIANA, *β.* SUBRADIATA, *Torr. & Gray, Fl. 2.*

* To the subdivision Eugaillardieæ, *Torr. & Gray, l. c.* belongs also the genus Cercostylis, *Less.*, which exhibits not only the style of Gaillardia (viz. a filiform hispid appendage rising abruptly from the more hispid tuft which surmounts the apex of the stigmatic portion), but likewise the same corneous subulate fimbrillæ of the receptacle.

† The original Palafoxia does not belong to the first section of this genus in the *Fl. N. Amer.*, which therefore cannot retain the name of *Eupalafoxia.* The paleæ of the pappus are equal, or the alternate ones slightly shorter in all three of the subgenera of the work above cited. In the true EUPALAFOXIA, containing P. linearis, *Lagasca* (which has been found in California by Coulter and Emory, along with a striking large variety ? having broadly lanceolate leaves and 30–40-flowered heads over an inch in length), the heads are entirely discoid and homogamous, two or three of the exterior flowers sometimes smaller; the scales of the oblong involucre equal; the lobes of the corolla much shorter than its elongated tubular-infundibuliform throat; and the four alternate paleæ of the pappus manifestly shorter.

P. Hookeriana, Texana, and callosa are all very handsome plants in cultivation, in the Cambridge Botanic

p. 368. Deep sand between Rabbit's Ear Creek and Willow Bar, Sept., and in the sandy bed of Dry Creek, near Bent's Fort. (455.) — Dr. Wislizenus gathered it in New Mexico, at the northern extremity of the Jornado del Muerto; with the exserted trifid rays, as in Fendler's specimens, half an inch long.

416. Schkuhria (Amblyopappus? v. Achyropappus § ligulis nullis) Neo-Mexicana (sp. nov.): strigoso-puberula, humilis; foliis inferioribus pedato-5–7-partitis, superioribus simpliciter 3-partitis segmentis lobisque anguste-linearibus; capitulis omnino discoideis 30-floris; acheniis lineari-cuneatis basi ad angulas villosis; pappi paleis 8 conformibus obovatis obtusissimis basi incrassato excepto enerviis corollam subæquantibus. — Margin of fields, Santa Fé; July, Aug. (458.) — Root annual. Stems 6 inches high, branched from the base; branches corymbose, bearing single or few heads (about as large as those of S. (Achyroppapus) senecioides, *Nees*) on slender peduncles. Leaves somewhat cinereous; the uppermost entire, and like the segments of the others, only half a line wide. Scales of the involucre about 10, pubescent outside, nearly as long as the disk. Achenia slender, conspicuously hairy on the angles towards the attenuated base. Branches of the style tipped with a very short conical appendage. Corolla yellow. — This plant entirely accords with Achyropappus except that it has no rays. It closely resembles Schkuhria multiflora, *Hook. & Arn.* (*in Jour. Bot.* 3. *p.* 322), from Mendoza, which is also rayless; but the pappus of that species consists of narrower and acutish paleæ, less thickened at the base, the alternate ones with a percurrent, or sometimes excurrent, midnerve. These plants, therefore, with the uniligulate S. Bonariensis, *Hook & Arn. l. c.*, appear inevitably to connect, not only Achyropappus, *H. B. K.*, but also Amblyopappus, *Hook & Arn. in Jour. Bot. l. c.*, with Schkuhria; one of the species of which (S. virgata, *DC.*) is said sometimes to want the solitary ray. Unless there is some diversity in habit beyond what the published character of Amblyopappus would indicate, this name should be preserved for the section of Schkuhria comprising these many-flowered homogamous species with awnless pappus. — Hopkirkia, *DC.*, it would appear from a plant in the collection of Dr. Wislizenus,* must also be reduced to Schkuhria.

Garden. Some indigenous specimens of the latter, gathered in Texas by Mr. Wright, have many of the achenia with an abortive pappus. Mr. Wright has also communicated some fruits of what would appear to be the same species, except that the achenia are glabrous, and entirely destitute of pappus.

* Schkuhria Wislizeni (sp. nov.): tenella, pube scabra subcinerea; foliis plerumque trisectis, lobis filiformibus; involucro unibracteato 4-phyllo 4–5-floro; floribus omnibus tubulosis hermaphroditis vel unico brevissime ligulato; acheniis obpyramidatis angulis longe villosissimis; pappo corollam subæquante, paleis 4 ex angulis achenii ovatis obtusis nervo valido excurrente breviter aristatis, 4 alternis similibus sed muticis

417. HYMENOPAPPUS FLAVESCENS (sp. nov.): floccoso-tomentosus vel incanus, demum glabratus; caule apice corymboso; foliis 1–2-pinnatipartitis lobis linearibus, ramealibus integerrimis vel basi lobulis 1–3 instructis; capitulis dense corymbosis; involucri squamis circiter 8 ovatis viridibus apice petaloidea corollisque luteis; acheniis villosis; pappo conspicuo corollæ tubo dimidio breviore, paleis obovatis integerrimis. — Between San Miguel and Las Vegas, New Mexico; Aug.: (464), with the lobes of the leaves broadly linear. Also a form of the same, with finer lobes to the cauline leaves, in deep sand a few miles west of Willow Bar of the Cimarron; Aug. in fruit (463); and near the Cimarron by *Dr. Wislizenus.* — Plant 15 inches high, bearing a rather ample corymb of larger heads than those of H. corymbosus; the appressed involucral scales petaloid only towards the apex and edges, where they are tinged, like the corolla, with a decidedly yellow color. The achenia and pappus are more nearly as in H. artemisiæfolius. Lobes of the leaves from one to three lines in width. Limb of the corolla broadly campanulate, longer than the lobes, both together about the length of the glandular tube. — In Dr. Wislizenus's specimen, the earlier, white-woolly radical leaves are simply pinnatifid, or some of them almost entire; the succeeding bipinnately divided; the corymb very large and full.

† 418. H. TENUIFOLIUS, *Pursh; Torr. & Gray, Fl. 2. p. 373.* Prairies, Ojo de Bernal to Rock Creek, New Mexico; Aug. (465.)

419. H. LUTEUS, *Nutt.; Torr. & Gray, l. c.* Along the sloping sides of dry hills, Santa Fé; May to July. (456.) — These beautiful specimens, the larger over a foot in height, show the plant more fully developed than the original ones of Nuttall. The full-grown heads are half an inch in length and diameter; and the appressed scales of the involucre are a little tinged with purple at the tip. The anthers also appear to have been purplish; but the corolla is cream-color, or pale-yellow, and its teeth much shorter than the cylindraceous throat, which exceeds the tube in length. The spatulate or narrowly

nervo evanido. — High mountains around Cosiquiriachi in the Sierra Madre west of Chihuahua, Oct., *Dr. Wislizenus.* — Annual; the stem 5 to 9 inches high, bearing few or rather numerous paniculate heads. Leaves minutely glandular-punctate, as in many Heleniæ; the lowest opposite and often simple, linear-filiform; the others mostly alternate and 3-parted, with the filiform lobes entire or rarely 2–3-lobed; the uppermost again simple. Heads about as large as in S. abrotanoides; the obovate scales of the involucre petaloid (tinged with yellow) at the summit. Tube of the corolla glandular, the limb 4-lobed; the pistillate flower, observed in only two out of twenty capitula, with an obovate ligule, not larger than the perfect flowers. Pappus at length tinged with purplish, the ample paleæ entire, the awned tips of the alternate ones equalling or at length exceeding the corolla.

oblong scales of the pappus are nearly as long as the tube of the corolla, but are concealed by the long villous hairs of the achenium.*

* Chænactis denudata, *Nutt. in Jour. Acad. Philad.* (*n. ser.*) 1. *p.* 177, from Pueblo de los Angelos, California (*fide spec. in herb. Lowell.*), is the same as C. lanosa, *DC.* The subjoined appears to be an undescribed species: —

Chænactis filifolia (*Harv. & Gray, in Pl. Coult. ined.*): subarachnoidea, demum glabrata; caule corymbosi-ramoso usque ad apicem folioso; foliis pinnatipartitis (summisve simplicibus); segmentis 5–9 rachique filiformibus integerrimis; pedunculis brevibus non glandulosis; corollis (flavis) radiantibus infundibuliformi-ampliatis irregularibus discum non superantibus; pappi paleis 4 oblongis obtusis æqualibus. — California, *Coulter.* — Heads about as large as in C. lanosa. Lobes of the leaves entire, more slender and sparse than in C. tenuifolia. In that species the scales of the pappus in the disk are unequal, lanceolate, and acute or acuminate. In this they are much shorter and broader, obtuse or rounded, and erose at the apex, especially those of the ray. — There is another species in Fremont's, and also in Hartweg's, Californian collection, which is exceedingly well marked by the great inequality in the paleæ of the pappus, viz.: —

C. heterocarpha (*Torr. & Gray, Fl. ined.*): annua, nana, lanosa, demum glabrata; caule folioso plerumque simplici monocephalo; foliis pinnatipartitis, segmentis 4–9 anguste linearibus breviusculis integerrimis rachi subangustioribus; pedunculo eglanduloso capitulum majusculum eximie radians vix duplo excedentibus; corollis (aureis) radiantibus infundibuliformi-ampliatis, limbo irregulari discum superante; achenio hirsuto; pappo disci e paleis 4 lanceolato-oblongis obtusissimis corollam æquantibus et 4 alternis parvis obovatis 5–6-plo brevioribus. — California, *Fremont* (third expedition), *Hartweg* (no. 1792). — Plant 3 to 5 inches high, rather slender, leafy to within an inch of the head, the stronger specimens inclined to branch above and bear one or two additional heads. Leaves an inch and a half long; the lateral lobes two or three lines in length, almost filiform. Head larger than in C. lanosa, nearly equalling that of C. achilleæfolia: involucre half an inch long. The somewhat palmate limb of the radiant corollas is four lines broad when expanded; the lobes as long as the tube. Pappus of the radiant flowers as in the disk, but shorter.

The following appears to constitute a distinct genus, which should probably stand (perhaps with Amauria, *Benth.*) next to Chænactis rather than with the Madieæ, notwithstanding the total absence of pappus.

ACARPHÆA, *Harv. & Gray, in Pl. Coult. ined.*

Capitulum multiflorum, homogamum; fl. omnibus tubulosis, exterioribus ampliatis subradiantibus. Involucrum campanulatum circ. 24-phyllum; squamis biseriatis, lanceolatis, discum æquantibus, planis. Receptaculum nudum, planum. Corollæ, tubo glanduloso-pubescente, disci graciles 5-dentatæ; radii sursum infundibuliformi-ampliatæ, 5-lobæ, limbo subirregulari. Antheræ exsertæ. Styli rami filiformi-subulati, hirtelli (ut in Chænactide). Achenia omnia (ut videtur) fertilia et conformia, lineari-clavata, subcompressa, multistriata, glabra, calva, extima paulo incurvata, in squamis involucri haud occulta. — Herba erecta, viscido-puberula; foliis alternis 2–3-pinnatisectis; capitulis paniculato-corymbosis; floribus luteis.

A. artemisiæfolia, *Harv. & Gray, l. c.* — California, *Coulter.* — Herb apparently three feet high, naked above: the root unknown. Leaves 3 or 4 inches long, petioled, glandular-hoary, especially underneath; the pinnæ, segments, and lobes linear or oblong, obtuse, numerous and approximate. Involucre half an inch long; the outer scales herbaceous; the inner narrower and more scarious, not complicate. Marginal corollas scarcely longer than the others. The achenia are immature, but apparently all fertile; the outer are not at all involved

420. Bahia oppositifolia, *DC. Prodr.* 5. *p.* 656. (Trichophyllum oppositifolium, *Nutt.! Gen.* 2. *p.* 167.) In ravines and low places, from eight miles east of Santa Fé to Cold Spring, on the Cimarron; August. (469.) — This long-lost plant has also been recently gathered by Mr. Geyer on the Upper Platte, and by Lieut. Abert on the frontiers of New Mexico. The spreading, branching stems, a span or little more in height, apparently rise from a creeping rootstock, and, like the 3-parted leaves, are cinereous or canescent with a close pubescence, but not tomentose. The uppermost leaves are often alternate. The scales of the campanulate involucre are somewhat lax, as in B. absinthifolia; the rays short, but sometimes considerably exserted; the achenia glabrous and minutely glandular; and the scales of the pappus have an opaque midnerve (which is unusually distinct and percurrent in Geyer's specimens) and are otherwise more membranaceous than in the Eriophylla. — This plant is certainly a congener of the original Bahia of Lagasca, viz. the Chilian B. ambrosioides (on which Nuttall founded his genus *Stylesia*), and of the Mexican B. absinthifolia. These, with an undescribed Mexican species,* constitute the typical section of the genus, which is to be distinguished from the section (rather than genus) Eriophyllum, *Lag.* by the loosely campanulate involucre, the scales of which are membranaceo-herbaceous and more or less spreading in fruit; by the paleæ of the pappus of a more membranaceous texture, but thickened at the base or axis or manifestly one-nerved; and by being merely cinereous or canescent, not clothed with floccose wool. The paleæ of the pappus in B. ambrosioides are not altogether nerveless, as characterized by Nuttall, but have a more or less thickened axis. Nor can the branches of the style be said to be "terminated by a *minute* cone," but they are better described by Hooker & Arnott (*in Jour. Bot.* 3. *p.* 321), as bearing a fleshy, apiculate cone, instead of having the truncate styles of Eriophyllum. In fact, the conical appendage of the branches of the style is quite large: in B. oppositifolia it is much the same, but smaller and obtuse; in B. absinthifolia it is penicillate-truncate with

by the involucral scales; and there is no chaff on the receptacle. The generic name accordingly refers to the absence both of the chaffy pappus of Chænactis, and of the chaff of the receptacle of the Madieæ.

* Bahia dealbata (sp. nov.): herbacea, tomento brevi subdecidua? undique argenteo-cana; foliis oblongis lanceolatisve integerrimis seu cuneatis trifidis basi trinervatis; ramis apice 1–2-cephalis nudis; involucri squamis obovatis acutiusculis; pappo corollæ tubum æquante, paleis 7 obovatis obtusissimis æqualibus nervo valido percursis. — Valley between Mapimi and Guajuquilla, and at Cadenas, Chihuahua, *Dr. Gregg;* April, May. — Stems ascending, 6 or 8 inches long; the base and the root wanting. Lower leaves opposite, the upper alternate, all petioled, an inch long, some entire, others with two spreading and lanceolate or linear entire lobes. Heads, the numerous and rather elongated rays, style, &c., nearly as in B. absinthifolia, but the scales of the involucre broader; the whole plant uniformly whitened with a pulverulent tomentum, which may be rubbed off.

a very minute apiculate cone. On the other hand, the conical appendage is manifest in some of the Eriophylla, as in B. leucophylla. If the two genera are to be restored, they must bear the names originally imposed by Lagasca. Eriophyllum trolliifolium, *Lag.*, which is yet to be identified, is certainly of a different genus.*

421. Actinella argentea (sp. nov.): caulescens, undique sericeo-incana; caulibus (4–10-uncialibus) inferne ramosis adscendentibus apice longe aphyllo monocephalis; foliis integerrimis oblanceolatis nitento-sericeis, imis rosulatis spathulatis 3-nerviis, caulinis superioribus linearibus uninerviis; involucri squamis 3-seriatis lanceolatis; pappi paleis lato-ovatis breviter aristatis, nervo evanido. — Gravelly and stony hills, around Santa Fé; April to June. (457.) — This showy species most resembles A. acaulis; but is larger, and apparently does not grow in dense tufts; the branching stems are leafy to the middle, and the silky pubescence of the leaves is closer and more silvery. The larger specimens are ten inches high; and the stems apparently continue to produce flowering branches through the summer. The heads, with the expanded rays, are fully an inch and a half in diameter. Ligules 15, cuneate, half an inch long. Receptacle hemispherical. The silky achenia and the pappus are silvery-white; the latter of broader paleæ with shorter awns than in A. acaulis. — The latter was gathered by Dr. Wislizenus between Rabbit's Ear and Rock Creeks; and Dr. Gregg found at Buena Vista an allied species with narrower and glabrate leaves, which I take to be a taller form of A. Torreyana.†

* Bahia arachnoidea, *Fisch. & Lallem. in Ind. Sem. Hort. Petrop.* 1842, remarkable for its dilated rhombic or cuneiform and barely lobed leaves, and for a very short pappus, was also gathered at San Francisco, California, by the U. S. Exploring Expedition. B. latifolia, *Benth. Voy. Sulph. p.* 30, from Bodegas, would appear to be the same species, with more lobed leaves; but the short paleæ of the pappus are more than four in our plant, and the heads are smaller than those of Bahia lanata.

† Two species have been added to this genus by Fremont, viz. the A. grandiflora, *Torr. & Gray, in Bost. Jour. Nat. Hist.*, collected in his first expedition, which has pinnately-parted simple leaves, and leafy stems, bearing a head nearly as large as that of Gaillardia aristata; and the following: —

Actinella depressa (*Torr. & Gray, Fl. ined.*): nana, escaposa, multiceps, caudicibus dense cæspitosis oblongis foliis anguste linearibus punctatis glabratis basi vaginata imbricante lanatissimis suffultis capitulo arcte sessili terminatis; pappi paleis 5–6 ovatis acuminato-aristatis corolla disci paulo brevioribus. — Rocky Mountains, apparently at a great elevation, the locality unknown, *Col. Fremont;* collected in the second expedition. The thick, matted stems are only an inch high; and the heads, which are nearly as large as those of A. acaulis, are strictly sessile and immersed among the very woolly bases of the leaves. Rays yellow. Paleæ of the pappus more or less thickened along the axis.

Var. β. pygmæa: caudicibus cum capitulo globulosis; foliis junioribus cano-sericeis, annotinis glabratis. — Raton Mountains, April, 1848, *Mr. A. Gordon.* — The specimens, with some other interesting plants

† 422. A. SCAPOSA, *Nutt.*, var. MUTICA: pappi paleis obtusis muticis vel in paucis mucronatis corolla disci 2–3-plo brevioribus; foliis sæpius integerrimis. (A. glabra, *Nutt.?*) — Woodlands, from Pecos to San Miguel; Aug. (466.) — The size and shape of the paleæ of the pappus and the length of their awn vary considerably in A. scaposa, both in Texan and North-Mexican specimens (from Buena Vista and Carrizitos, *Dr. Gregg*), some of which exhibit the shorter paleæ of the present variety; and "on the Arkansas" Dr. Wislizenus gathered a closely related form, in which the paleæ are slightly awned or awnless, and some of the leaves are lobed. The leaves become glabrous. I suspect that this will prove to be the A. glabra of Nuttall, but have no specimen for comparison.

423. A. RICHARDSONII, *Nutt.; Torr. & Gray, Fl. 2. p.* 381; var. FLORIBUNDA. Rocky hills, as well as plains and creek-bottoms, around Santa Fé; June, July. (460.) — The stems are taller than in Richardson's plant from Carlton House (from a span to a foot high), and branch copiously and repeatedly above, the branchlets terminated by single heads, so as to form a broad fastigiate corymb. The somewhat woody caudex and the base of the stems are woolly, as also in the original plant. The heads (as usually happens when increased in number) are smaller than in the original specimens and in the figure by Hooker, but I perceive no further difference. The involucre and the whole characters of this plant are closely like those of Hymenoxys (Oxypappus) odorata, *DC.*, although in that plant the tube of the corolla is a little longer and the pappus denticulate. De Candolle's second section of Hymenoxys must therefore be reduced to Actinella, leaving in the former genus only the discoid (South American) species.* Ptilomeris,

from the same district, kindly sent to me by Dr. Engelmann, came to hand while this sheet was undergoing revision. These are much smaller than those of Fremont, measuring only half an inch from the root proper to the top of the head, which is also smaller; but it is plainly a form of the same species. — Mr. Gordon also gathered, on the sources of the Canadian, Actinella acaulis, and the species mentioned above as a taller state of A. Torreyana, *Nutt.* The caudexes of the latter are rather slender, surmounted by slender scapes of four or five inches long; the pappus in the ray is awnless, but in the disk short-awned.

* ACTINELLA ODORATA (Hymenoxys, *DC.*), which appears to be an annual, was gathered by Col. Emory in Western New Mexico; by Dr. Wislizenus at Bachimba, below Chihuahua; and by Dr. Gregg farther south, at Bolson de Mapimi, where he states that it forms a "broadly conical bunch of two feet in height and diameter." The local name is "*Manzanilla Cimarron.*" — It is also in Mr. Gordon's collection, from towards the sources of the Canadian.

The collection of Dr. Wislizenus furnishes a new plant of this group, well distinguished from Actinella and its allies by the small and flat receptacle, and by a pappus of a dozen barbellulate bristles which are membranaceously margined towards the base; from which character I have proposed for it the name of

Nutt., which I referred to Hymenoxys in the *Flora of N. America*, is doubtless distinct, as Mr. Nuttall insists.* The naturalists of the Exploring Expedition met with this

HYMENOTHRIX, *Nov. Gen.*

Capitulum multiflorum, heterogamum; fl. radii 8–10 ligulatis fœmineis, disci tubulosis. Involucrum turbinatum, disco brevius, e squamis circiter 10 lanceolato-oblongis, subbiseriatis, æqualibus, appressis. Receptaculum parvum, planum, nudum, papillosum. Ligulæ spathulato-oblongæ, apice 3-dentatæ, discum haud superantes. Corollæ fl. hermaph. elongatæ, tubo gracili minutim glanduligero, fauce infundibuliformi 5-loba lobisque margine vix incrassatis glabris. Antheræ ecaudatæ, exsertæ, appendicula ovata superatæ. Styli rami fl. hermaph. lineares, cono brevi superati. Achenia lineari-cuneata, sub 4–5-gona, glabriuscula. Pappus simplex, radii et disci conformis, corolla paulo brevior, e setis 12–13 equalibus sursum barbellulatis infra medium membranula hyalina lanceolata integerrima utrinque limbatis. — Herba annua? amara, subglabra; caule erecto corymboso; foliis alternis petiolatis biternatisectis, segmentis integris vel trifidis lobisque linearibus; capitulis corymbosis; floribus radii et disci flavis.

✓ H. Wislizeni. — Grassy places, Ojo de Gallejo, between El Paso del Norte and Chihuahua, August, *Dr. Wislizenus.* — Stem two feet high, rigid, loosely and amply corymbose at the summit; the branches, leaves, involucre, &c., minutely appressed-puberulent. Lower leaves triternately, the upper biternately, dissected; those of the branches 3–5-parted, or the uppermost simple; the segments a line or less in width, half an inch or more in length. Heads 4 lines long, on slender and minutely bracteate peduncles; the fully developed flowers nearly twice the length of the herbaceous and appressed involucre. Disk-corollas 3 lines in length, fully as long as the spreading rays; the sinuses between the ovate lobes slightly unequal. Branches of the style narrowly linear, semicylindrical or more flattened, glabrous, or minutely puberulent on the back, the prominent stigmatic lines extending to the base of the short, minutely bearded cone with which they are tipped. Pappus longer than the achenium, formed of narrow and diaphanous paleæ with a very strong midrib which is gradually excurrent into a prolonged, barbellate-denticulate awn. — I know of no genus of Euheleniæ with which this plant can be immediately compared, except Chætymenia, *Hook. & Arn.* (*in Bot. Beech.*, which the authors refer to Tagetineæ), Burrielia, *DC.*, and Oxypappus, *Benth.* In habit, foliage, &c., it is very unlike either of these: the pappus is much as in the former; but the style differs widely from the description and figures of this and the last-named genus.

* It appears to me almost certain that both *Ptilomeris* and *Dichæta* of Nuttall should be united to Burrielia, *DC.*, with the character a little extended as to the pappus. Ptilomeris affinis, *Nutt. in Jour. Acad. Philad.* (*n. ser.*) 1. *p.* 174, differs from P. aristata s. Californica, *Nutt.*, only in having the scales of the pappus minutely pectinate-ciliate down the sides; and from P. coronaria, *Nutt.*, only in the want of awns. A specimen of P. tenella, *Nutt. l. c.*, accords exactly in the pappus, and sufficiently so in other respects, with the anterior P. mutica, *Nutt.* The achenia of the ray are certainly fertile in some specimens of several, if not all, of these plants; nor do I find them infolded in the involucral scales any more than in Burrielia. The subjoined species technically belongs to Dichæta, but differs from Burrielia (especially B. gracilis) only by having very short and obtuse scales of the pappus interposed between the aristiform ones, and in the sparingly lobed leaves: —

✓ Dichæta Fremontii (*Torr. ined.*): caulibus e radice annua adscendentibus gracilibus; foliis anguste linearibus nunc integerrimis nunc segmenta filiformia utrinque 1–2 gerentibus; squamis involucri et ligulis late ovalibus 8; pappo ex aristis 4 e basi subulata setiformibus tubum gracillimum corollæ subsuperantibus et

species between the Wallamet River and California; and a low form, with the heads even smaller than in Fendler's plant, exists in Fremont's third collection, apparently from the interior of the south part of Oregon. — Mr. Fendler gathered a monstrous state of this species, with the flowers of the head all pedicellate, so as to form an umbel, the pappus transformed more or less into bract-like lobes, the corolla prolonged and more herbaceous, the anthers distinct, &c.

squamis totidem parvis truncatis 2–3-fidis alternantibus. — California, *Fremont* (1846). — Heads as large as those of Burrielia gracilis; the branches of the style tipped with a similar capitate cone; while in B. microglossa and B. gracilis the appendage is more slender.

A more striking case of diversity in the pappus of plants which are otherwise almost undistinguishable occurs in Layia, *Hook. & Arn.* (Madaroglossa, *DC.*; Eriopappus, *Arn.*), Callichroa, *Fisch. & Mey.*, Calliglossa, *Hook. & Arn.*, and Calliachyris, *Torr. & Gray*, which it is becoming evident should all be viewed as sections merely of a single genus, to which perhaps even Oxyura, with no pappus at all, will ultimately be added. Thus combined, the sections of the genus would be characterized thus: —

LAYIA, *Hook. & Arn. Bot. Beech. p.* 148 (non *p.* 182).

§ 1. MADAROGLOSSA, *DC.* (Eriopappus, *Arn.*) Pappi aristæ setiformes, basin versus pilis tenuissimis prælongis lanato-plumosæ seu villosæ: receptaculum inter flores radii et disci tantum paleaceum.

Layiæ sp., *Torr. & Gray*, *Fl.* 2. *p.* 393, excl. no. 1. — L. elegans, which has been gathered by Coulter, Fremont, Hartweg, &c., occasionally is destitute of the crisped and interlaced wool of the inside of the pappus, which is then consequently less villous than in the other species, and connects this typical group with the third section.

§ 2. LAYIA, *Hook. & Arn.* Pappus ut in § 1: receptaculum inter flores disci exteriores paleaceum.

L. gaillardioides, *Hook. & Arn. l. c.* I have seen this species only in a collection made in California by some Russian botanist.

§ 3. CALLICHROA, *Fisch. & Meyer.* Pappi aristæ ut in § 2–3 sed nudæ: receptaculum inter flores radii et disci tantum paleaceum.

L. platyglossa. Callichroa platyglossa, *Fisch. & Mey. Ind. Sem. Hort. Petrop. & Sert. Petrop. fol. & t.* 5 (excl. syn. Madar. heterotr. *Hook.*).

§ 4. CALLIGLOSSA, *Hook. & Arn. l. c. p.* 356. Pappus e paleis inæqualibus subulato-aristiformibus achenio brevior, basi dilatata pl. m. ciliato-setigera, constans: receptaculum totum paleaceum.

L. Calliglossa. Oxyura, *Lindl. Bot. Reg.* (ex parte). Calliglossa Douglasii, *Hook. & Arn. l. c.*; *Fisch. & Mey. Sert. Petrop. fol. & t.* 6. — The wild specimens from the Russian collections show well the irregular hairs which fringe the base of the chaffy awns, plainly representing the longer hairs of Layia proper.

§ 5. CALLIACHYRIS, *Torr. & Gray.* Pappus e paleis (circ. 12 subæqualibus achenium æquantibus) ovato-lanceolatis, apice subulato-cuspidatis, nudis, vel basi pilis longis paucis interpositis: receptaculum etc. Calliglossæ.

L. Fremontii: humilis, diffusa; tubo cor. disci pubescente. Calliachyris Fremontii, *Torr. & Gray in Bost. Jour. Nat. Hist.* 5. *p.* 140. California, *Fremont* (in his second, and also in the third expedition), *Hartweg.* — The hairs sparingly interposed between the dilated scales of the pappus (much like those which clothe the achenium, though longer) are similar to the more abundant ones of L. heterotricha.

†424. Helenium autumnale, *Linn.* Bottom-land near the Mora River, August (467); and between Council Grove and Fort Leavenworth, Sept. (468.)

✓ †425. Amauria? dissecta (sp. nov.): herbacea, puberula; caule adscendente apice corymbosi-polycephalo; foliis alternis petiolatis biternatisectis segmentis cuneiformibus vel sublinearibus sæpius 2–3-fidis, summis parvis; pedunculis glandulosis; involucri squamis oblongo-lanceolatis subtriseriatis, intimis subscariosis; receptaculo convexo; ligulis circiter 16; styli ramis fl. disci cono brevissimo truncati-capitatis; acheniis ad angulos lævibus. — A few miles east of Mora River; Aug. (537.) Also gathered in Fremont's third expedition, probably towards the head-waters of the Arkansas. — Stem 12 or 15 inches high, apparently from a perennial root. Leaves about an inch in diameter, cut into narrow divisions. Peduncles clothed both with viscous and capitate-glandular hairs. Involucre herbaceous, more or less viscous, a third of an inch in diameter. Receptacle entirely destitute of chaff. Flowers all yellow: rays linear-oblong, 2–3-toothed; the tube very glandular. Disk-corollas with the slender tube extremely glandular, the expanded 5-cleft limb slightly so. Branches of the style short, flattish-semiterete, capitate with a very short and flattish obtuse cone. Achenia cuneate-linear, slender, compressed-quadrangular, smooth; the ovary sprinkled with sparse and minute hairs. Pappus none. — The specimen of Fendler has not matured fruit; and the stamens are abortive in all the disk-flowers. The specimen from Fremont's collection, communicated by Dr. Torrey, is very imperfect, but has ripe achenia. From the character of the Californian genus Amauria, *Benth. in Bot. Voy. Sulph. p.* 31, this plant differs very essentially in the styles, and in the convex receptacle. But I am unwilling to constitute it a distinct genus upon the present imperfect materials.*

* Galinsoga parviflora, *Cav.*, was gathered by Dr. Gregg at Saltillo, and by Dr. Wislizenus at Cosiquiriachi, Chihuahua. The specimens from the latter locality have the pappus of the ray reduced to a few setiform squamellæ, and also in other respects agree with the Vargasia Caracasana, as described by De Candolle; but not with the figure in *Deless. &c. Sel.* 4. *t.* 47, where the pappus of the ray is represented nearly like that of the disk, and the latter as much shorter than the corolla instead of "paleæ corolla triplo longiores." Probably the Vargasia, *DC.*, is not even specifically distinct from Galinsoga parviflora, as Mr. Bentham has intimated. At Monterey, Dr. Edwards and Major Eaton gathered Tridax procumbens, *Linn.*; and Dr. Wislizenus's collection contains a single specimen of a second species, with red or purple rays, viz.: —

✓ Tridax bicolor (sp. nov.): annua, humilis, glanduloso-pubentissima; caule erecto; ramis apice modice nudis monocephalis; foliis oblongis vel lanceolatis integerrimis (an semper); paleis receptaculi oblongis longe acuminatis; ligulis rubris cuneati-oblongis breviter 3-lobis; pappo purpurascente e setis circiter 20 achenium æquantibus corolla disci atque tubo ligularum dimidio brevioribus. — At Llanos in the Sierra Madre, west of Chihuahua, *Dr. Wislizenus:* flowering in November. — The specimen is only a span high, somewhat cine-

426. ACHILLEA MILLEFOLIUM, *Linn.* Moist meadows and foot of mountains along Santa Fé Creek; June – Oct. (509.) Also a variety with rose-colored flowers.*

reous with a viscous pubescence and, especially the summit of the branches (which are leafless for only one or two inches), hirsute with glandular-capitate hairs. Heads nearly as large as those of T. procumbens: but the ligules are considerably longer and "red" according to the note of Dr. Wislizenus: in the specimen some of them are of a deep pink-purple, others of a lighter hue. Disk-corolla (light-yellow), styles, achenia, and pappus nearly as in T. procumbens, except that the pappus is much shorter. The ligules exhibit two small interior lobelets, just as Sogalgina, *Cass.* is characterized (a genus which otherwise does not seem to be very distinct); but as I notice a similar, although single, often emarginate, small lobelet, in Tridax procumbens, I do not hesitate to refer our plant to that genus.

* The following is a very striking, chiefly New-Mexican genus of Anthemideæ-Chrysanthemeæ: —

BAILEYA, *Harv. & Gray, in Pl. Coult. ined.*

Capitulum 16 – 500-florum, heterogamum; fl. radii 6 – 60, ligulatis, fœmineis, 1 – 3-serialibus, marcescenti-persistentibus; disci tubulosis hermaphroditis. Involucrum lanatissimum 1 – 2-seriale, e squamis linearibus æqualibus appressis constans. Receptaculum planum, nudum. Ligulæ ovales vel cuneatæ, 7-nerviæ, apice 3-lobæ, basi unguiculata sessiles (tubulo nullo), post anthesin papyraceo-membranaceæ, persistentes. Corollæ disci cum ovario atomis resinosis conspersæ; tubo brevi; fauce infundibuliformi breviter 5-dentata; dentibus ovatis glanduloso-barbulatis. Styli rami fl. hermaph. apice truncato barbatuli. Achenia lineari-oblonga, prismatica, vel subteretia, multistriata, glabra, basi apiceque truncata, omnino calva. — Herbæ humiles, ut videtur biennes, undique albo-lanosissimæ; foliis alternis pinnatifidis seu integris; capitulis solitariis longe pedunculatis speciosis; floribus flavis post anthesin pallescentibus. — This genus is dedicated to *Prof. J. W. Bailey*, of the U. S. Military Academy, who is particularly distinguished for his researches among the minuter Algæ and especially the Diatomaceæ (which he was the first to detect in a fossil state in this country), for his microscopical investigations concerning the crystals contained in the tissues of plants, and for the detection of vegetable structure in the ashes of anthracite. Through B. pauciradiata this genus is not obscurely allied to Riddellia, which belongs to the same region, and which it imitates in the persistence of the dilated rays. But in the lineal series it would appear to stand next to Monolopia. There are three species known, viz.: —

* *Oliganthæ, villoso-lanatæ.*

1. B. PAUCIRADIATA (*Harv. & Gray, l. c.*): diffuse ramosissima; foliis (imis ignotis) caulinis et ramealibus linearibus integerrimis; pedunculis subcorymbosis; involucri campanulati squamis 8 – 10 uniserialibus; ligulis 5 – 6 ovalibus subtridentatis brevissime unguiculatis; floribus disci 10 – 12; acheniis subclavatis elongatis valde striatis muricato-scabris. — California, *Coulter.* — Stems 6 or 8 inches long (the base unknown), villous, like the leaves, &c., with lax or spreading woolly hairs. Peduncles filiform, an inch long. Rays 3 lines long, reflexed, overlapping each other, as long as the narrowly campanulate involucre.

* * *Myrianthæ, floccoso-lanosissimæ.*

2. B. PLENIRADIATA (*Harv. & Gray, l. c.*): caule ramisque simplicibus strictis apice longe nudis; foliis inciso-pinnatifidis vel paucidentatis, summis parvis linearibus integerrimis; involucri late campanulati squamis 20 – 30; ligulis 25 – 40 obovato-dilatatis breviter unguiculatis involucro longioribus post anthesin deflexis et pluriseriatim imbricatis; fl. disci 40 – 50; acheniis subprismaticis utrinque truncatis lævibus vel globulis resi-

† 427. ARTEMISIA DRACUNCULOIDES, *Pursh. Fl. 2. p. 742; Torr. & Gray, Fl. 2. p. 416.* Bottom of the Mora River; Aug. (511.)

nosis pl. m. conspersis. — California, *Coulter.* Valley of the Rio Nazas, &c., in Chihuahua, *Dr. Gregg;* flowering in April and May. — Plant from 8 to 16 inches high; the radical leaves somewhat bipinnatifid, with few segments; the upright branches naked above for the length of 4 or 6 inches, and bearing solitary heads (like Bahia leucophylla), which are nearly an inch in diameter with the rays outspread. These at maturity are five lines long and over three in width, at length reflexed over the involucre, which they conceal, in several series: although not really so numerous as in the next species, yet they are more strikingly imbricated, being more dilated and arranged around a smaller disk. The minutely bearded apex of the branches of the style exhibits in this species a more or less distinct central mucronation or slight cone: in the others they are absolutely truncate.

3. B. MULTIRADIATA (*Harv. & Gray, l. c.*): caule subsimplici vel basi ramoso ramisque adscendentibus superne longe nudis; foliis 1–2-pinnatifidis summisve parvis integris; involucro late hemisphærico polyphyllo; ligulis circiter 50 oblanceolato-cuneatis sensim unguiculatis involucrum triplo superantibus. — *Torr. in Emory's Report, p. 144. t. 6.* — California, *Coulter.* Interior of California near Hernandez' Spring, *Fremont.* Along the Rio del Norte, New Mexico, and in the region between it and the Gila, *Col. Emory.* Sandy plains near Albuquerque, *Dr. Wislizenus.* Near Chihuahua and valley of Rio Conchos, *Dr. Gregg.* — A stouter, and, when branched, a more spreading plant than the last; the leaves more pinnatifid; and the showy golden-yellow heads about twice as large, being over an inch and a half in diameter, including the narrowly oblong-cuneate rays, which are half an inch long. Achenia nearly as in the last, sprinkled with minute resinous globules.

Dr. Gregg and Dr. Wislizenus both collected a shrubby Composita, apparently of Anthemideæ-Athanasieæ (but this is uncertain), which I am unable to refer to any known genus. I have therefore characterized it, under its popular appellation, as given in Dr. Gregg's memoranda: —

VARILLA, *Nov. Gen.*

Capitulum discoideum, homogamum, multiflorum; fl. hermaphroditis. Involucrum turbinatum, imbricatum, pauciseriale, disco brevius; squamis subulatis. Receptaculum conicum, paleis angustissime linearibus (superne paulo dilatatis) onustum. Corollæ fauce cylindrica e tubo brevi gracili subito dilatata, 5-dentata, dentibus ovatis revolutis glabris. Antheræ exsertæ ecaudatæ. Styli rami compressiusculi, extus minutissime puberuli, cono brevissimo obtuso pubero terminati. Achenia conformia, oblonga, subteretia, multicostata, pappo brevi setuloso coronata; setulis circ. 15 ex costis achenii ortis, simplicibus vel paucis subramosis. — Suffrutex glaber, parum viscidulus, foliosissimus; foliis oppositis summisve alternis, elongato-linearibus, uninerviis, integerrimis; capitulis fastigiato-corymbosis; floribus luteis.

V. MEXICANA. — Between Pelayo and Cadena, in the State of Chihuahua, *Dr. Wislizenus;* May. Valley east of Parras, *Dr. Gregg;* April. — This is said to form a low shrub of two to three or five feet in height. The leaves are two or three inches long, and one or two lines wide, rather thick. The heads are numerous in rather dense terminal corymbs, a quarter of an inch long; the short peduncles with subulate bracts which pass into the scales of the involucre. These are rather rigid and appressed, yellowish, with slightly scarious margins. The paleæ are similar, but narrower and longer, equalling the flowers, minutely glandular. Corolla with the tube glandular, otherwise glabrous. Anthers linear, yellow. Achenia black, much shorter than the

428. A. Canadensis, *Michx.; Torr. & Gray, Fl. l. c.* Rocks, two miles east of the Mora River; Aug. (510): also between Bent's Fort and Santa Fé; Oct.

†429. A. filifolia, *Torr. in Ann. Lyc. N. Y. 2. p.* 211; *Torr. & Gray, Fl. l. c.* Between Rock and Rabbit's Ear Creeks; Aug. — This is a characteristic plant of the plains, from the south bank of the Arkansas, *Dr. Wislizenus*, to Santa Fé. Dr. Wislizenus also gathered it at Valverde, north of the Jornado del Muerto.

†430. A. discolor, *Dougl.?* (The heads unexpanded.) Santa Fé.

†431. A. Ludoviciana, *Nutt.; Torr. & Gray, Fl. 2. p.* 420. Valley of Santa Fé Creek; July (513): Poñi Creek; Aug. (514): also near Council Grove; Sept. (515).

†432. A. vulgaris, *Linn.?* Santa Fé Creek: an incomplete specimen. (518.)

†433. A. frigida, *Willd.* Prairies, &c., Poñi Creek and Rock Creek, New Mexico; Aug. to Oct. (512.)

434. Gnaphalium Sprengelii, *Hook. & Arn. Bot. Beech. p.* 150; *Torr. & Gray, Fl. 2. p.* 427. Low places in mountain woodlands, between Santa Fé and Vegas; Aug. — Dr. Wislizenus collected the same species at Chavez, New Mexico, north of the Jornado.*

✓ 435. Antennaria dioica, *Gærtn.* Hills at the foot of the higher mountains above Santa Fé, chiefly on the northern declivities; June. The masculine plant (521 and 523), and the fertile (521) with the leaves either green above or tomentose; also (524) a form of the fertile plant with rose-colored involucres. — In Geyer's Oregon collection, no. 542 is a remarkable new Antennaria, which, probably from external resemblance only, Sir Wm. Hooker has referred to the Chilian Gnaphalium alienum, *Hook. & Arn. in Jour. Bot. 3. p.* 329. That plant is described as a true Gnaphalium, with about six hermaphrodite flowers in the centre. My specimen from Geyer is a staminate plant, with the pappus manifestly clavate.†

corolla, about 15-ribbed, some of the ribs stronger, thus appearing angular. Pappus as long as the breadth of the achenium.

* Gnaphalium ramosissimum, *Nutt.! in Jour. Acad. Philad.* (*n. ser.*) 1. *p.* 173, is the same (except that the involucre is not tinged with rose-color) as G. Sprengelii, β. erubescens, *Nutt. in Trans. Amer. Phil. Soc.* (*n. ser.*) 7. *p.* 403, which in the *Flora of North America* was doubtfully appended to G. Californicum; but it is probably a distinct species.

✓ † Antennaria Geyeri: argenteo-lanata, spithamæa; caulibus floridis e basi suffrutescente plurimis subsimplicibus ad apicem usque foliosis oligocephalis; foliis spathulato-linearibus densissime lanosis; involucris (pl. sterilis) cylindraceis lanatissimis, squamis oblongo-linearibus apice obtusiusculo scarioso tantum nudatis stramineis, intimis roseo tinctis; pappi setis barbellato-denticulatis superne sensim longeque clavellatis. — Gnaphalium alienum, *Hook.! Lond. Jour. Bot.* 6. *p.* 251, non *Hook. & Arn.* — "Arid, sandy woods near

†436. Erechtites hieracifolia, *Raf.* East of Council Grove; Sept. (481.)

437. Senecio exaltatus, *Nutt. in Trans. Amer. Phil. Soc.* (*n. ser.*) 7. *p.* 410. Var. minor (1–2-pedalis), foliis radicalibus fere ovatis vel obovatis. Valley of Santa Fé Creek, at the foot of mountains, ten miles above Santa Fé; April to June. — This is the same as my specimen of no. 297 of Geyer's Oregon collection, referred to S. exaltatus by Hooker, with the remark that the species varies greatly. It probably includes S. cordatus, *Nutt.* The name is not appropriate for these smaller forms; but some of them are tall and stout.

†438. S. aureus, *Linn.* Santa Fé Creek; June. A small state; the rounded radical leaves deeply crenate-toothed.

439. S. aureus, γ. borealis, *Torr. & Gray, Fl.* 2. *p.* 442. Santa Fé Creek, at the foot of hills; May, June.

†440. S. filifolius, β. Fremontii, *Torr. & Gray, Fl.* 2. *p.* 244. Pawnee Fork, and 27 miles south of Bent's Fort; Sept. — Except in the shorter lobes of the leaves, especially the terminal one, this species differs but slightly from the next.

441. S. longilobus, *Benth.! Pl. Hartw. no.* 127: — a form with canescent leaves, some of them often undivided. Hills and sides of mountains around Santa Fé. (470.) Also gathered in New Mexico by Dr. Wislizenus, Col. Emory, and Lieut. Abert.

442. S. longilobus, *Benth. Pl. Hartw. l. c.:* a glabrate form. Along the valley of Santa Fé Creek. (†472, 473.)

443. S. eremophilus, *Richards. Appx. Frankl. Journ. ed.* 2. *p.* 31; *Hook. Fl. Bor.-Am.* 1. *p.* 334. Santa Fé Creek-bottom; June and Oct. Also met with by Fremont, in his second expedition.

444. S. Fendleri (sp. nov.): perennis, floccoso-incanus, demum subglabratus; caule folioso erecto pedali corymbosi-ramoso; foliis oblongis omnibus pinnatifidis supra glabratis inferioribus in petiolum nudum attenuatis summis sessilibus haud amplexicaulibus, segmentis 11–21 confertis oblongis obtusissimis plerisque inciso-dentatis seu 2–4-lobatis; corymbis compositis polycephalis; involucro campanulato fere ecalyculato 12-phyllo multifloro; ligulis 7–8 oblongis disco duplo longioribus; acheniis glaberrimis. — Foot of mountains along the Creek, twelve miles above Santa Fé; June, July. (478, †480.) — A well-marked species, related to S. eremophilus. Stem stout. Leaves from 2 to 4 inches long including the petiole, some of the lower often only sinuate-pinnatifid, but commonly all deeply pinnatifid or pinnately parted, the crowded lobes from one fourth to

Tshimakaine, Spokan country," in Northern Oregon, *Geyer.* — The heads with unexpanded flowers (little over two lines in length) are sessile and nearly spicate at the summit of the stems; but the vestiges of the previous year show them to have been corymbose.

half an inch long, early glabrate above; but still floccose or white-woolly underneath. Involucre 3 lines long. Rays 4 or 5 lines long.*

* Senecio Tampicanus, *DC.*, is in Dr. Gregg's collection, from a "low valley of the Rio del Parral near Santa Rosalia." It bears the marks of having been floccose at an early stage. — Nearly allied to this is

Senecio multilobatus (*Torr. & Gray, Fl. ined.*): annuus seu biennis, citissime glaber, pedalis, multicaulis; caulibus simplicibus apice corymbiferis; foliis subcarnosis, primariis spathulatis sæpe indivisis, sequentibus omnibus pinnato-9–21-partitis, inferioribus longe petiolatis, summis sessilibus basi vix aut ne vix auriculatis, segmentis cuneato-oblongis apice inciso-dentatis vel 2–3-lobatis; corymbo denso polycephalo; involucro fere ecalyculato 12–14-phyllo; ligulis 5–6 oblongis; fl. disci 20–30; acheniis strigoso-puberulentis. — Abundant on the Uintah River, in the interior of California, *Fremont* (second expedition). — Var. β. foliis inferioribus magis interrupte pinnatisectis, pinnis majoribus lobatis. Monterey to San Gabriel, *Coulter.* — Heads as large as those of S. aureus.

Another unpublished Californian species, which was gathered by Fremont in his third expedition, is

S. eurycephalus (*Torr. & Gray, Fl. ined.*): perennis? glabratus; caule pedali crasso simplici; foliis sublyrato-pinnatipartitis inferioribus longe petiolatis summis sessilibus; segmentis 7–11 oblongis cuneatisve apice incisis grosse et argute dentatis, infimis parvis, superioribus sensim majoribus confluentibus; capitulis magnis 7–9 in corymbum laxum digestis longe pedunculatis; involucro late campanulato parce calyculato circiter 24-phyllo multifloro; ligulis 10–12 elongatis; acheniis glaberrimis. — California, *Fremont;* also *Hartweg.* — Radical leaves somewhat bipinnatifid, the lowest cauline on petioles of from two to four inches long and exceeding the lyrate lamina, the upper lobes all confluent; the succeeding cauline leaves less lyrate, and with more numerous segments, which are about half an inch long, cut into coarse and pointed teeth. Involucre half an inch in diameter. Rays over half an inch long. Pappus very copious.

At Llanos, Dr. Wislizenus gathered a perfectly glabrate form of S. Hartwegi, *Benth.* The achenia are entirely glabrous, and the stem herbaceous.

On account of its *opposite leaves*, its involucre of only four or five broad scales, and the scanty pappus, the following plant of Dr. Gregg's collection appears to constitute a distinct genus, viz.: —

HAPLOËSTHES, *Nov. Gen.*

Capitulum globosum, multiflorum, heterogamum; fl. radii 4–5 ligulatis, fœmineis; disci tubulosis hermaphroditis. Involucrum uniseriale, e squamis 5 late ovalibus plurinerviis constans, ecalyculatum. Receptaculum convexum nudum. Ligulæ late ovales. Corollæ fl. disci 5-dentatæ, sub 10-nerviæ, nervis accessoriis ad medium loborum directis. Antheræ, styli, et achenia (immatura) omnino Senecionis. Pappus uniserialis, e setis capillaribus tenuissimis vix 20, corolla disci paulo brevioribus. — Herba glaberrima, ramosa, gracilis; foliis oppositis filiformibus integerrimis; capitulis parvulis laxe corymbosis; floribus flavis.

H. Greggii. — Valley near Cieñega Grande, Coahuila, *Dr. Gregg;* May. — Plant 2 feet high, erect, with a terete stem and branches, leafy. Root unknown. Leaves all opposite, one or two inches long. Corymb naked. Peduncles slender. Involucre herbaceous, slightly yellowish, two or three lines in diameter. Rays broadly oval, scarcely two lines long, 7-nerved. The accessory or median nerves of the disk-corolla are as strong as the others, but are nearly wanting in one or two of the lobes. Immature achenia terete, glabrous. Pappus of 15 or 20 minutely scabrous capillary bristles.

† 445. Tetradymia inermis, *Nutt.; Torr. & Gray, Fl. 2. p.* 447. Sunny side of a hill near Santa Fé; July. A shrub three feet high; only a single shrub was met with. — T. canescens, *DC.*, to which the above species too nearly approaches, is also shrubby, as is shown by specimens sent by Mr. Spalding from Kooskooskee River.

446. Cirsium canescens, *Nutt. in Trans. Amer. Phil. Soc.* (*n. ser.*) 7. *p.* 420? Foot of mountains around Santa Fé, on the sunny side; May, June. (485.) — The specimens are fully two feet high, clothed with floccose white wool, with the leaves decurrent into rather prolonged but narrow and very spiny wings. Heads smaller than in C. undulatum; the flowers apparently ochroleucous.

† 447. C. ochrocentrum (sp. nov.): caule foliosissimo erecto foliisque subtus lanugine densa incanis; foliis pinnatifidis sessilibus summis subdecurrentibus supra arenosis, lobis brevibus sæpe bifidis (radicalibus pinnatisectis, pinnis elongato-lanceolatis acuminatis inciso-pinnatifidis) spinis flavicantibus horridis, capitulis subsolitariis ad apicem ramorum foliosorum sessilibus; involucri globosi squamis glabris in spinam validam flavidam abrupte desinentibus. — Mountain-sides, around Santa Fé; July. (486.) — The radical leaves are described from specimens of what I take to be the same species, although there are no flowering stems, gathered by Dr. Gregg in the valley of Saltillo, in March. That plant is said to attain three feet in height. Fendler's specimen is only a foot high, with the cauline leaves from 4 to 6 inches long, white, and very spiny; the longer spines and still stouter ones which tip the scales of the involucre half an inch in length and yellowish (whence the specific name). Heads rather small, less than an inch in diameter. Corolla apparently pale-purple.*

* The following is from Coulter's Californian collection: —

Cirsium Coulteri (*Harv. & Gray, in Pl. Coult. ined.*): arachnoideo-tomentosum; caule ramoso; foliis caulinis oblongo-lanceolatis subamplexicaulibus undulatis sinuatis spinescentibus supra laxe arachnoideis; capitulis maximis ebracteatis solitariis; squamis involucri arachnoideo-lanosissimi laxe imbricatis rectis demum patentibus omnibus e basi brevi lanceolata vel oblonga in appendicem acicularem prælongam apice cuspidatam sensim attenuatis. — California, *Coulter.* — Mature heads nearly two inches in diameter. Scales of the involucre all similar, but the inner successively longer; the slender and spine-like filiform appendages thrice the length of the dilated portion; the innermost as long as the (purple?) flowers; the outermost much shorter and at length reflexed. Filaments hairy.

The *Compositæ-Labiatifloræ* gathered by Gregg and Wislizenus in Northern Mexico are: —

Leria nutans, *DC., prodr.* 7. *p.* 42. Bishop's Hill, Monterey, *Dr. Gregg.* Also found in western Texas by Lindheimer and Wright.

Trixis corymbosa, *Don?* Near Ojito, *Dr. Gregg.*

Perezia runcinata, *Lagasca, Mss. ex Don.* Clarionea (Palesia) runcinata, *Don in Linn. Trans.* 16. *p.* 207; *DC. Prodr.* 7. *p.* 62. Bishop's Hill, Monterey (also coll. by *Dr. Edwards*); and at Cerralbo, *Dr.*

448. C. ALTISSIMUM, *Spreng.; Torr. & Gray, l. c.* High banks on the Arkansas; Sept. (584.)

Gregg. (Mr. Wright informs me that it abounds on the Rio Grande, Texas, and that he also met with it at Austin.) Flowers purple. Scape often bearing two or three heads. — Hitherto known only in the collection of Sesse and Moçino (*in herb. Lamb.*), from which it was described by Don, who cites the manuscript name of " Perezia runcinata," given to him by Lagasca. This name I restore, first, because the plant appears, judging from the figure in Delessert's *Icones Selectæ*, to be a strict congener of Perezia Gayana, *DC.*, and wants the spinulose-toothed exterior involucral leaves of Clarionea as characterized by De Candolle; and second, because the former name, being the earlier published, has been restored and the Candollian genera, apparently with good reason, united by Endlicher. — The following plants, with undivided leaves and purple flowers, and which have the copious bristles of the pappus by no means in a single series nor penicillate at the apex, as is said of Acourtia, I incline to refer to the same genus. But the genera of this tribe are still very far from being satisfactorily settled.

P. NANA (sp. nov.): caulibus e caudice lanato vix pollicaribus foliosis capitulo (pollicari) circa 20-floro haud longioribus; foliis cuneato-rotundatis sessilibus glabris minutim glanduloso-scabris reticulatis grosse et argutissime spinuloso-dentatis; involucri campanulati squamis 3–4-seriatim imbricatis integris subciliatis calloso-mucronatis, exterioribus ovatis, intimis oblongo-lanceolatis superne purpurascentibus; receptaculo tuberculati-alveolato, alveolis parce hirsuto-fimbrilliferis; ovariis glanduloso-puberis; pappo albo copiosissimo, setis pluriserialibus. — High and dry valley near Chihuahua, *Dr. Gregg;* April. — Leaves and heads each about an inch in length, very large for the size of the plant; but the specimens perhaps are stunted. Lips of the purple corolla nearly equal in length. Manifestly a congener of the succeeding.

P. WISLIZENI (sp. nov.): glaberrima; caule fere bipedali erecto simplici apice nudiusculo monocephalo; foliis indivisis glaucescentibus obovatis vel obovati-oblongis semiamplexicaulibus pulcherrime reticulatis marginibus crebre calloso-denticulatis, summis ad bracteas spathulatas reductis; involucro plusquam 50-floro hemisphærico atro-purpurascente glabro, squamis coriaceis 3–4-seriatim imbricatis subsquarrosis mucronulatis, exterioribus ovato-rotundis, intimis oblongis acuminatis; receptaculo subalveolato glabro; acheniis oblongo-linearibus glabris; pappo 2-seriali sordido. — Llanos, in the Sierra Madre west of Chihuahua, *Dr. Wislizenus;* Oct. — This striking plant is, I doubt not, a close congener of Clarionea carthamoides, *DC.*, judging from the figure given by Delessert, although the involucral scales are entirely destitute of teeth or cilia. The arid leaves are very beautifully reticulated, obtuse, their edges beset with minute salient teeth. The radical leaves are unknown: the larger cauline are four inches long and two or more in width, the narrowed base auriculate-clasping: the uppermost are much smaller, oblong, and half-clasping by a broader base. Head an inch in length and diameter. " Flowers red," deep purple in the dried specimens. Unripe achenia 4 lines long. Pappus half an inch in length, rather shorter than the corolla.

P.? PLATYPHYLLA (sp. nov.): lævigata; caule 2-pedali superne corymboso; foliis coriaceis (infimis ignotis) amplis rotundati-obovatis sinu acuto amplexicaulibus pulcherrime reticulatis crebre arguteque spinuloso-dentatis, ramealibus subhastatis parce dentatis; capitulis corymbosis subfasciculatis; involucri 12-flori turbinati squamis pauciusculis subtriseriatis ciliolatis purpurascentibus vix acutis, extimis ovato-lanceolatis, intimis lanceolatis; receptaculo nudo; acheniis glanduloso-puberulis; pappo albo 2–3-seriali. — Cosiquiriachi, in the Sierra Madre, west of Chihuahua, *Dr. Wislizenus;* Sept. — Stem rigid. Cauline leaves three inches long and almost as wide, strongly clasping by a short and narrowed deeply auriculate base, sharply serrate all

449. STEPHANOMERIA RUNCINATA, *Nutt.; Torr. & Gray, Fl. 2. p. 472.* (Jamesia pauciflora, *Nees in Neuwied. Trav.*) Foot of dry hills, Santa Fé; June, July.*

round with triangular rigid teeth; the rameal leaves much smaller and oblong. Heads numerous in a broad corymb, half an inch long. Corolla, &c., as in the foregoing. Bristles of the pappus copious, rigid, equally serrulate from the base to the apex, not at all penicillate. — This plant is doubtless an Acourtia of De Candolle, who, although he adopts the character "setis apice penicillatis" of Don, yet represents nothing of the kind in the figure of A. hebeclada in Delessert's *Icones*. The copious pappus of this plant also differs from his generic character in that the bristles certainly occupy more than one series. If, therefore, the characters of the pappus of Acourtia are rightly laid down, this plant does not belong to that genus. If not, there remains apparently no valid distinction between it and Perezia.

* Stephanomeria elata, *Nutt. in Jour. Acad. Philad.* (*n. ser.*) 1. *p.* 173, from the character is evidently the same as the earlier published S. virgata, *Benth. Bot. Voy. Sulph. p.* 32. It also occurs in the Californian collections of Coulter, Fremont, and of the Exploring Expedition.

The Oregon collection made by the Rev. Mr. Spalding contains specimens of two very interesting Cichoraceæ, which may be mentioned here, viz. an undescribed Calais, but which I suspect is the Hymenonema? glaucum of Hooker, and a new congener of Scorzonella (Ptilophora, *Torr. & Gray, ined.*) nutans, *Geyer, in Hook. Lond. Jour. Bot.* 6. *p.* 253.

CALAIS MACROCHÆTA (sp. nov.): subscaposa, glabrata; foliis linearibus acuminatis integerrimis vel sæpius remote pinnatilobatis subglaucis, junioribus villo molli caduco pubescentibus; scapo apice furfuraceo; involucri squamis extimis tertia parte brevioribus; acheniis lævibus apice rostrato-attenuatis; pappi paleis oblongis apice bifidis arista ex sinu exserentibus triplo brevioribus. (Hymenonema? glaucum, *Hook. Fl. Bor.-Am.* 1. *p.* 300? & Scorzonella glauca, *Nutt.*?) — Clearwater, on the Kooskooskee, Oregon, *Mr. Spalding.* — Root annual. The smaller specimens, with scapes 6 or 10 inches high, exhibit entire leaves, much like those of C. linearifolia. The larger, with scapes or peduncles 18 or 20 inches high, have broader and flat leaves, which mostly bear three or four short lobes or salient teeth on each side. The foliage is scarcely glaucous. The involucral scales are broadly lanceolate. The paleæ of the pappus are only five, just as in Calais, except that they are shorter and the naked awn is longer. These points being more or less at variance with the little that is known of Hooker's Hymenonema? glaucum, I do not venture to employ that specific name, nor to append it as a synonyme except with much doubt. — The shorter but long-awned paleæ of the pappus in this species, along with the lanceolate involucral scales of Scorzonella § Ptilophora might naturally suggest the propriety of uniting all these plants with Calais. This genus, however, consists of annual plants, with the conspicuous paleæ of the pappus only five in number and convolute around the base of the corolla, and the elongated achenium has a tapering or beaked summit. Scorzonella consists of tuberous-rooted perennials, with the barely oblong achenia not at all narrowed above, and with a pappus of *ten* paleæ which are so short as to appear merely like an abruptly dilated base to the long capillary awns. These are minutely denticulate: while in the section Ptilophora (which, now confirmed by a second species, may be raised to the rank of a genus, still more nearly allied to Scorzonera) the awns are plumose and from 14 to 22 in number.

PTILOPHORA, *Nov. Gen.*

Involucrum 20–40-florum, duplex; exterius brevius laxe calyculiforme, squamis ovato-subulatis; interius uniseriale, squamis lanceolatis sensim acuminatis. Receptaculum nudum, planum, subalveolatum. Ligulæ

†450. Hieracium longipilum, *Torr.; Torr. & Gray, Fl. 2. p.* 477. Eighty miles west of Independence, &c. (489, 503.)

†451. Nabalus asper, *Torr. & Gray, l. c. p.* 483. High prairies west of Council Grove; Sept. (473.)

452. Lygodesmia juncea, *Don; Torr. & Gray, l. c. p.* 484. Around Santa Fé; June, July (497): also Poñi Creek (496).—The juice, according to Fendler, is greenish-yellow.

†453. Malacothrix (Leptoseris, *Nutt.*) sonchoides, *Torr. & Gray, Fl. 2. p.* 486. Low, sandy banks of the Rio del Norte: May. (490.) — This is also in Coulter's Californian collection; which likewise contains a remarkable undescribed species, apparently of this genus.* I notice a singular character in M. sonchoides, M. Coulteri, and espe-

exsertæ. Achenia lineari-oblonga, teretia, multicostata, erostria, callo sublaterali. Pappus simplex uniserialis, niveus, e setis 14–22 gracillimis eleganter plumosis basi paleato-dilatatis constans. — Herbæ perennes glabræ; caule e radice fusiformi tuberosa erecto, ramoso; foliis integris vel pinnatilobatis, ramis superne longe nudis pedunculiformibus apice subincrassato monocephalis; capitulis ante anthesin nutantibus; floribus flavis.

✓ 1. P. nutans: gracillima; foliis angustissime linearibus elongatis e basi subamplexicauli sensim filiformi-attenuatis integerrimis seu pinnatilobatis, lobis filiformi-subulatis; involucro cylindrico 20-floro glabrato, squamis exterioribus subquinque, interioribus 8; acheniis scabridis extimis puberulis; paleis pappi oblongis seta plumosa 5–6-plo brevioribus. — Scorzonella (§ Ptilophora, *Torr. & Gray, Mss.*) nutans, *Geyer, Mss.* (under Crepis), *Hook. in Lond. Jour. Bot.* 6. *p.* 253. — "Dry, sunny, loamy declivities of Spokan and Cœur d'Aleine Mountains; June. Root nearly as large as the little finger, succulent and almost transparent, full of a bitterish milky juice, eaten raw by the Indians." *Geyer.* Also collected by the Exploring Expedition between Spokan and Colville. — The involucre when young, like the base of the stem, is slightly and minutely glandular-pulverulent; otherwise glabrous.

✓ 2. P. major (sp. nov.): foliis spathulato-lanceolatis inferne attenuatis vel in petiolum marginatum angustatis integerrimis seu laciniato-dentatis; involucro campanulato glandulosi-puberulo multifloro, squamis exterioribus 8–9, interioribus 10–13 subulato-acuminatis; ovariis glaberrimis; pappi setis ima basi tantum scarioso-dilatatis. — β. laciniata: foliis elongato-lanceolatis laciniato-pinnatilobatis, supremis integerrimis linearibus attenuatis; involucro fere glabro. — Clear Water, on the Kooskooskee, Oregon, *Mr. Spalding.* — Stems a foot or more in height, or in the var. β. lower. Leaves half an inch or more in width. Heads three fourths of an inch long, larger than in the foregoing species. Mature achenia unknown; but the fructified ovaries are very short, abrupt at both ends, and perfectly glabrous. The smoother involucre and the more slender foliage of the variety here indicated tend to unite this with P. nutans; but in the extremely short chaffy base of the setæ of the pappus, and in the more numerous involucral scales and flowers, it entirely accords with P. major.

Allied to this genus, but nearer to Oporinia, is no. 1815 of Hartweg's Californian collection, which before this, probably, has been characterized by Mr. Bentham.

* Malacothrix? (Malacolepis) Coulteri, *Harv. & Gray, Pl. Coult. ined.*): glaberrima, glaucescens; caule superne ramoso; foliis lanceolatis oblongisve inferne dentatis seu pinnatifidis basi auriculata amplexicaulibus, ramealibus cordato-amplexicaulibus acuminatis fere integerrimis; capitulis (magnis) subcorymbosis breviter pedunculatis; squamis involucri subglobosi multiflori pluriseriatim imbricatis omnino nisi costa

cially in M. Californica, namely, that two (opposite) bristles of the pappus are naked instead of barbellate, and rather stronger and less deciduous than the others.

✓ 454. Crepis ambigua (sp. nov. non *Balb.*): caule scapiformi e radice perenni simplici basi folioso apice racemoso-5–8-cephalis foliisque obovati-oblongis integerrimis setis patentibus sparsis hispidis cæterum glaberrimis; capitulis majusculis longiuscule pedunculatis circa 30-floris; involucro cylindrico hirto, squamis linearibus, extimis duplo breviori-bus appressis; ligulis (flavis?) genitalia haud superantibus; acheniis fusiformibus superne sensim angustatis multicostatis glaberrimis pappum albidum longitudine æquantibus. — Level, grassy places along Santa Fé Creek; June to Aug. — A foot high, from a thick perennial root, which yields a white juice; the purplish stem leafy only near the base, above nearly smooth and bearing one or two linear bracts. Leaves 2 or 3 inches long, sessile; the radical with a tapering base, hispid with slender bristles above, purplish underneath, resembling those of Hieracium Gronovii, β. subnudum. Heads two thirds of an inch in length. Ligules very short, little longer than the pappus, usually shorter than the styles. Mature achenia blackish, a third of an inch long, attenuated upwards, but not truly rostrate. Pappus copious, dull white, of bristles nearly as stiff as those of Hieracium, but occupying much more than one series; — on which account I refer the plant to Crepis (although the pappus is not bright white) rather than to Hieracium.

✓ 455. Macrorhynchus purpureus (sp. nov.): perennis; foliis e caudice crasso rosulatis linearibus integerrimis vel plerisque pinnati-3–7-lobatis acutis crassiusculis subglaucis glaberrimis; scapo aphyllo (6–8-pollicari) juniore floccoso-pubescente sub capitulo lanoso; involucri glabrati squamis 3-seriatis appressis purpureo pictis obtusiusculis, intimis linearibus extimas oblongas duplo superantibus; floribus (in sicc.) purpureis breviter ligulatis; acheniis lineari-fusiformibus æqualiter 10-costatis glaberrimis in rostrum scabridum iisdem pappoque paulo brevius attenuatis. — Grassy places, bottom of Santa Fé Creek; July. — Plant with the thick caudex and the aspect of a Troximon; but most of the densely clustered leaves (two or three inches long) bear a few short linear lobes about the middle. Scapes at length glabrous. Heads cylindraceous, two thirds of an inch long; the scales of the involucre mottled or spotted, or the broader exterior ones entirely painted, except the margins, with deep purple. Flowers purple; the ligule

viridi scariosis late ovalibus obtusissimis, intimis lanceolatis acutis. — California, *Coulter*. — A foot high, stout; the root unknown. Leaves 2 inches long. Heads 10 lines in diameter. Flowers, ovaries, and pappus as in Malacothrix; but the scarious involucre is very remarkable. The fruit is unknown.

Remarkably large specimens of Malacothrix Californica, with coarser foliage, and the head, including the expanded rays, two inches in diameter, were collected by Dr. Gambell at Pueblo de los Angelos and distributed under the name of " Macrorhynchus laciniatus."

short. Achenia slender, half an inch long including the beak. Pappus one third of an inch long, of minutely scabrous and, for this genus, rather rigid bristles, but finer than in Troximon roseum, *Nutt.* — From its resemblance to the present species and the short beak of its half-formed fruit, I suspect that T. roseum also is a Macrorhynchus; but its pappus is absolutely as well as relatively longer (half an inch in length) than in this plant, its involucral scales all more prolonged and acute, its ligules smaller, &c.*

456. Taraxacum palustre, *DC.*, var. latifolium: foliis spathulato-oblongis obtusissimis. (T. montanum, *Nutt.! in Trans. Amer. Phil. Soc. (n. ser.)* 7. *p.* 430, non *DC.*) Banks of Santa Fé Creek; May. (†495, 500, 501.) — The leaves in a specimen from Nuttall are half an inch, in Fendler's fully an inch, in width, sinuate-toothed; those towards the base often narrower and sharper, and runcinate-reflexed.†

†457. Lactuca elongata, γ. sanguinea, *Torr. & Gray, Fl.* 2. *p.* 496. East of Mora River; August. (491.)

458. L. graminifolia, *Michx.*, approaching L. elongata by the runcinate-pinnatifid radical leaves. — Santa Fé Creek in the mountains; July. (504, †505.)

459. Mulgedium pulchellum, *Nutt.* Loose, gravelly soil, Santa Fé Creek; July. (506.) Also Rock Creek, &c. (492.)

†460. M. Floridanum, *DC.; Torr. & Gray, Fl.* 2. *p.* 498. Council Grove. (494.)

461. Sonchus oleraceus, *Linn.* Fields around Santa Fé; July. (507, †508.)

†462. S. asper, *Vill.; Torr. & Gray, l. c. p.* 501. Waste places, Santa Fé. (502.)

* Specimens of Troximon glaucum, β. dasycephalum, *Torr. & Gray*, in Geyer's Oregon collection (no. 666) and in that of Mr. Spalding, with the heads sometimes an inch and a half in diameter, and the leaves lanceolate or oval-lanceolate, often coarsely toothed, and an inch and a quarter wide, evidently constitute the T. taraxicifolium, *Nutt.*, from the same region.

† At Saltillo, Dr. Gregg collected a Dandelion, which is doubtless Taraxacum Mexicanum, *DC.*, with the young leaves somewhat hairy, and the neck and whole scape at first very woolly, but becoming naked with age. The achenia are nearly smooth towards the base.

*** For Hymenatherum gnaphalodes, p. 90 (note), I desire, by a slight change, to substitute the name Hymenatherum Gnaphalopsis, and to cite as a synonyme the Gnaphalopsis micropoides, *DC. Prodr.* 7. *p.* 248 (inter Compos. incertæ sedis). De Candolle founded this genus upon a plant gathered at Monterey, New Leon, in the month of January, by Berlandier. Although he describes his plant as diœcious? with an involucre of exterior subfoliaceous scales and an inner series of distinct, glabrous scales, observed no ligules, describes the pappus as consisting of only five paleæ, and makes no mention of globular pellucid glands under the wool of the leaves, &c., yet I am confident of its identity with Dr. Gregg's plant (which really accords in none of these respects) from the same habitat, and gathered at the same season of the year. The specimen examined probably was very imperfect, and with the ray-corollas fallen or abortive. Much finer specimens of our plant (from Gregg's collection) have just reached me, with the stems branching after the manner of Micropus, and four inches in length; and a reëxamination confirms all the characters previously assigned.

Rudbeckia? Porteri, p. 83 (note), has been found anew by H. W. Ravenel, Esq., during the past summer, in the mountains of Georgia. A capitulum, just received in a letter from my friend Mr. Curtis, exhibits the fructiferous disk considerably prolonged, and the ripe achenia short and thick, obscurely quadrangular.

The subjoined is a Cruciferous plant which was not received in time to be noticed in the proper place: —

SYNTHLIPSIS, *Nov. Gen.* Crucif.-Thlaspid.

Calyx basi subæqualis, sepalis linearibus laxis. Petala obovata, ungue lato. Discus hypogynus inter petala et stamina annularis, contorto-undulatus. Filamenta edentula, filiformia. Ovarium oblongum, multiovulatum, stylo gracili brevius: stigma depresso-capitatum. Silicula septo contrárie compressa, oblongo-elliptica, emarginata (vel immatura leviter obcordata); valvis navicularibus acutissime carinatis, apteris, apice tantum marginato-subproductis; septo lato-lineari uninervi. Semina in quovis loculo 8–10, biserialia, e funiculo libero pendula, orbiculata, compressa, immarginata. Cotyledones planæ, septo contrariæ, radiculæ adscendenti carinam valvarum spectanti accumbentes. — Herba ramosa diffusa, pube stellata canescens; foliis sinuato-pinnatifidis; racemis laxis; floribus ut videtur roseis; pedicellis fructiferis patulis vel recurvis.

S. Greggii. — Valley near Saltillo, Coahuila, January 4, 1847, *Dr. Gregg.* — Root and radical leaves not seen. Stem apparently low, diffusely branching, rigid; the branches, like the whole plant, whitened with a close and fine stellate pubescence, leafy. Leaves oblong, coarsely sinuate-toothed or pinnatifid; the lower narrowed into a petiole; the others almost sessile. Petals 3 lines long, evidently tinged with purple or rose-color. Pods 4 or 5 lines long, and 2 lines or a little more in width, canescent, about the length of the pedicel, flattened contrary to the narrow septum, pretty strongly emarginate at the apex, tipped by the slender style; the compressed-navicular one-nerved valves sharply carinate, but the keel scarcely if at all margined, except at the apex, where it is manifestly produced. — The specimen upon which this evidently new genus is founded occurs in a collection by Dr. Gregg, long since forwarded to me by Dr. Short, but which has only now come to hand. Although the genus must be referred to the Thlaspideæ, its nearest affinity is with Vesicaria through the Mexican V. argentea, *Schauer* (which I have in fruit from Coulter's Mexican collection, no. 691), in which the silicle is evidently somewhat compressed contrary to the elliptical septum, but the cotyledons are still parallel with it; and with Physaria (vide *Gray, Gen. Ill.* 1. *p.* 162) through P. Geyeri (Vesicaria Geyeri, *Hook.*), in which, moreover, the seed hangs with the cotyledons contrary to the septum, as in the present genus. It is also allied to the Californian Lyrocarpa, *Hook. & Harv.* In aspect it bears considerable resemblance to the Dithræa Wislizeni of Engelmann; — a flowering specimen of which, gathered by Mr. Gordon, near the sources of the Canadian, exhibits a pair of ovules in each cell. The name, σύνθλιψις, *compression*, alludes to the character of the pod which distinguishes the genus from Vesicaria and Physaria.

Dr. Gregg's collection also contains specimens, gathered "west of Parras," of a canescent plant with much the habit of Synthlipsis Greggii, but with linear-oblong pods (siliques rather than silicles), a cordate-capitate stigma, &c.: but the immature seeds seem as if the cotyledons would be incumbent. Better materials are requisite for its proper determination.

*** Page 63, line 19, for no. "348" read 342.

(To be continued.)

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II.

A Memoir upon the Geological Action of the Tidal and other Currents of the Ocean.

By CHARLES HENRY DAVIS, A. M., A. A. S., etc.

LIEUTENANT U. S. NAVY.

(*Communicated to the Academy, November 8th*, 1848.)

The views presented in the following memoir are derived from a study of the tidal currents on our northern and northeastern shores for the last six years, during which time I have taken part, as hydrographical assistant, in the survey of the coast of the United States, conducted under the able superintendence of Professor A. D. Bache.

This portion of our coast abounds in alluvial and subaqueous deposits, the most numerous, and perhaps the most striking, examples of which occur on and about the island of Nantucket. It is particularly in the survey of this district that I have been led to trace the connection between the currents and the shoal formations which give a peculiar character to its navigation. The changes that are supposed to take place in these shoals are the subject of popular inquiry, and this inquiry could only be satisfactorily answered by an investigation into their mode of formation, and the probable causes that determine their shape and locality.

Having arrived at some definite views concerning the relation of the currents in this immediate vicinity to the deposits below the surface, and to those that have been raised above the water by the transporting power of the winds, such as hooks, beaches, &c., it was an easy and natural step, first, to extend the reasoning suggested by these humble instances to the more grand subaqueous and alluvial deposits at a distance from this continent, on the shores of Europe, and elsewhere; and afterwards, remembering that the laws of nature are constant, uniform, and universal, to consider how far the same modes of operation have been employed, in previous geological periods, in distributing or collecting the loose materials of the earth's surface.

Whilst occupied with these inquiries, it was my good fortune to have with me, as a guest, Mr. Edward Desor, a gentleman too well known in the world of science to need

any commendation at my hands. He entered cordially into my views, assisted me in gathering and arranging the details of this memoir, and supplied, from his abundant stores of ready knowledge, the most conspicuous and valuable examples of tidal and current action in past geological ages.

It has been suggested by Mr. Desor, as well as by other friends in whose judgment I have great confidence, and who, like himself, were not previously familiar with the subject of the tides generally or with the nature of tide-currents, that this memoir would be more intelligible if it were preceded by a short treatise upon the dynamical action of the tides, and of the streams generated by resistance to the motion of the tidal undulations, or by other causes affecting the condition of the ocean. But it has been considered, on the other hand, that the object of this memoir is to introduce a new theory to the notice of the scientific world, which has already in its possession the means of testing the accuracy of the principles upon which the theory is based. The long and able series of "Researches on the Tides," by Dr. Whewell, have supplied the necessary information on this subject; and any statements comprising such practical details as come under the special observation of the hydrographer will be referred to competent authority.*

The satisfactory treatment of this subject, moreover, would embrace a wide range, commencing with the theoretical origin of the tidal currents, and terminating with graphical illustrations of the variable and complicated action of streams passing from the open sea into wide bays, meeting in sounds, conflicting with the courses of rivers, or following the irregularities of an indented and broken coast: it must also include some of the ocean currents. It has been thought best, therefore, upon reflection, to defer a popular account of the following views to another time and place. This account will embrace the distribution of the coralline detritus, which belongs equally to the subject, though designedly omitted in this memoir.

Section I. — *Upon Shoals, and their Relation to the Currents of that Part of the Sea in which they are found.*

There are certain inequalities in the bottom of the ocean, particularly that part of it near the land, which give a distinctive character to the navigation of the region in which they are found. The inequalities to which I refer are known by the generic name of

* I have referred particularly to the "Researches" of Dr. Whewell, rather than the discussions of Sir John Lubbock; because it is the form, progress, transmission, interference, &c., of tide-waves, and the establishment of ports, that are to be dealt with, and not those variable phenomena of the tides depending upon changes in the moon's place or upon atmospheric influences.

shoals, by which is meant formations composed of loose and light materials, easily suspended by the water, and carried about by its motions and agitations.

Shoals, in the vocabulary of seamen, are, strictly speaking, spots of shallow water, dangerous to vessels, generally isolated in situation, of comparatively small extent, and rising from the surrounding ground in such a manner as to interrupt the channels in or near which they lie. Shoals are most frequently found in great numbers in the same place, and not, like rocks, single; this feature of their existence is connected with, and dependent upon, the form and material of the neighbouring land. They are also found where there are currents caused by the flux and reflux of the tide, by the regularly uniform changes of the ocean, by occasional and local disturbances, or by the conflict between rivers and the waters into which they empty.

Examples of shoals the most striking in number, extent, and relative position are to be met with where the action of the tides is equal, permanent, and marked, and where the land around which they are deposited is composed of materials similar to their own. Such is the case on the southeastern coast of New England.

The navigation here is rendered peculiarly dangerous by numerous shoals, among which the tides ebb and flow with regularity, having a rise and fall of four or five feet; and the shores both of the continent and islands consist almost entirely of the same mineralogical substances as the shoals themselves.

From among these, that group known as the *Nantucket South Shoals* has been selected as the most characteristic, and as the best suited to illustrate the views which it is the object of this memoir to disclose. Occasional reference, however, will be made to other shoals on the southern coast of Massachusetts.

It will be readily observed, upon an inspection of the chart of the Nantucket Shoals (Plate I.), that there is a conformity between the shores of Nantucket island and the shoals themselves in their place and direction. On the south side of the island, where the shore runs east and west, the shoals called the "Old Man," "Old South Shoal," and "New South Shoal," lie more nearly in that direction than on the east side. There they follow the north and south direction of the island. There is but little doubt that a complete survey of this region will assign the same general conformity of outline to the external soundings. Numerous specimens of the shoals have been collected, and they are found without exception to be identical in composition with the island. Nantucket, as may be easily seen at the sandy bluffs in any part of the island, is composed of quartzose sand deposited in layers; which is the material of the shoals also, with this difference, that the sand of the latter is somewhat finer, as if it had been subjected for a longer time to the action of water.

This correspondence in direction and similarity of material imply the existence of an intimate relation between the deposits above and below the water; and as it is apparent that the causes which have produced the latter, whatever they may be, are not sudden or accidental, but, on the contrary, continued and regular, it is to be expected that the same or similar causes should now be discovered in operation.

The most prominent feature of a shoal, which is its rise above the ordinary level of the surrounding ground, proves that the mode of its formation is different from that of the bottom of an inclosed basin of quiet water, where the matter in suspension is deposited horizontally. This difference has been attributed to the action of the waves of the sea. If this supposition were true, shoals should be more numerous than they really are, and they should be constructed according to the direction of the prevailing winds. Lakes, moreover, are wanting in shoals, which would not be the case if they were produced by waves alone. The effect of the agitation of water by waves over a nearly uniform surface is to distribute materials, not to heap them up; as is shown by the level bottom of a shallow pond. That shoals are not the result of wave-action alone, then, is proved by the universal fact, that their form has no connection with prevailing winds, by their absence in lakes, and by the general distributive, rather than constructive, tendency of waves.

Recurring again to the similarity of materials of the shoals and the adjacent land, to the facility of their transportation, and to the regular and constant movements of the water effected by the tides, it remains to consider the influence of the tidal currents. If this influence operates, it should show itself in various ways; the shape and direction of the shoals should correspond to the course and action of the tides. The Nantucket South Shoals are in general long and narrow. They lie where the daily ebb and flow of the tides are rapid and, during the greater part of their period, steady in direction; and the direction of the tides is also that of the shoals. The south shore of the island, from Smith's Point to Siasconsett, runs, as was said before, east and west. At Siasconsett the land turns gradually to the north, so that the shore from this place to Great Point lies nearly north and south.

The tides that cause the flux and reflux of the waters pressing upon the island follow the outline of its shores. The flood, for example, commencing with a nearly easterly direction on the south side, passes gradually round to the north on the east side, following the trend of the land. The reverse is the case with the ebb. As the distance from the shore increases on the south and east sides, the direction of the tides is modified by the remoter influences which govern the progress of the tidal wave along this part of the coast.

It may be stated, in general terms, that the tidal wave which supplies this part of the coast approaches it in a direction between north and west, but is deflected to the east by the banks that lie between the Gulf Stream and the main, known in the technical language of seamen as "soundings on the coast." The general course of these banks answers to that of the shores, which from New York begin to turn to the eastward. Farther from the island of Nantucket, therefore, the easterly direction of the flood inclines to the northward, and the westerly direction of the ebb to the southward. Now, the shoals in the vicinity of Nantucket conform so nearly to the courses of the tides as to leave no doubt that they are indebted to them for their form.

The shoal called the "Old Man," on the south side (see Plate I.), lies nearly east and west, while the "Bass Rip" on the east side has a north and south direction.

The "Old South Shoal," at a distance of twelve miles, and situated where the flood tide takes a more northerly course, lies about northeast and southwest.

Without multiplying these instances, it can be safely asserted that the same law of conformity is exemplified in all the principal shoals of this extensive group. This view is further illustrated by noticing the configuration of these shoals, which as a whole may be regarded as a system of curved elevations concentric with the island of Nantucket, and though the members of any one series may be separated by deep water suited to the purposes of navigation, yet the relation below the surface can be frequently traced, either by similarity of material, or by comparatively smaller depths along their line of connection. These separations must be regarded as the channels preserved by the flow and ebb of the tide, through which the great body of the water that passes among the shoals finds its principal vents.

Between the several series, the intervening space is marked by striking differences of depth and bottom. The shoals themselves are composed, as has been said, of sand; but in the valleys between there are dead shells, coarse gravel, pebbles, and stones, the latter abounding in animal life, in which the shoals are entirely deficient; showing that there is not merely a difference of level, but a real distinction in origin and composition.

Hitherto I have spoken principally of the form and composition of the shoals in their relation to the bottom at large; but there are peculiarities in their individual structure worthy of special notice on account of their close resemblance to certain forms common in the drift deposits of New England and Northern Europe. One of the most striking of these peculiarities is the ridgy character. The top of the shoal is not an even surface, like a plain, but its outline is rounded, and frequently broken into several long and narrow summits, or ridges, crowded closely together, and in general parallel to the main axis of the shoal.

The depth of water on the shoal is so small, that the top is subjected to a destructive action of the waves and currents, producing other inequalities of level. There are drains or "slues," as they are called by seamen (probably a corruption of *sluices*), through the ridges, similar to the channels in the deltas of rivers. These drains result from the agitations of the sea, and from the lateral pressure of the tides, which, running parallel to the direction of the ridges, and being higher than their summits, are forced over them, so that *at* the shoals the tides, both flood and ebb, appear to run at right angles to their real line of direction.

The drains or slues run in the direction of the ebb tide. This is in accordance with the prevailing law of operation of the tides, which makes the ebb the most influential in preserving and creating channels.

To return to the materials of the shoals. The particles of sand, even the most minute, are smoothed and rounded by the action of the water; they appear to be finer as they are farther from the shore, and in their mineralogical character they agree exactly with the sand of Martha's Vineyard, Nantucket, and, it may be added, the coast of Cape Cod.

Parts of these islands undergo constant changes, sufficiently rapid to be plainly perceptible in a few years. I have undoubted testimony, from living and intelligent witnesses, that the beach extending along the southeast part of Martha's Vineyard has been washed away for the breadth of one mile in the term of fifty years, leaving the remains of the former beach as a line of detached shoals, between which and the present shore there is now deep water. In 1839–41, the cliff or bank at Siasconsett fell twice, carrying with it the last time about twenty-five feet of the top. One dwelling-house, and some small buildings, were precipitated into the sea. Several other houses standing on a line with these were saved by being moved in time. These disasters were caused by an unusually high tide, and by a violent gale from the east-northeast. The destructive action of the waves upon prominent headlands is well understood. At a point in the Vineyard Sound called West Chop (see Plate I.), the light-house was removed two years ago farther inland, the water having washed away and undermined that part of the bank on which the old light-house stood. A similar change is taking place at Cape May, and many such instances might be cited from books of authority; but the general fact is too well known to require additional confirmation.

From these sources, then, there proceeds a constant supply of loose materials, which are subjected to the action of the water. These materials are undoubtedly carried away by the currents, and as the shoals or other deposits are found in their course, it is a necessary conclusion that they are the products of their action. But there should exist some

cause why the suspended matter is found in particular places, and in great quantities: and this cause, it may be readily conceived, must be the natural inequalities in the level of the bottom, which, interrupting the stream, not only take up a portion of its burden, but occasion the eddies that, as I shall have occasion to show hereafter, are especially favorable to deposit. The inequalities need not be very great. Small impediments at the mouths of harbours, or in rivers, serve this purpose of a nucleus. A vessel sunk in a spot where the water is loaded with sand or mud collects around it a deposit by which it is wholly covered in a short time. This is often exemplified on various parts of our coast. Where the attempt has been made to rescue valuable property from ships that have remained for a long time sunk in such places, a part of the task has generally been to remove the covering under which they were buried. At the late meeting of the American Association for the Promotion of Science, Mr. Dickeson related a remarkable incident of this kind, where, at the island of Galveston, in 1839, a vessel from New Orleans was wrecked (at the south end), with a considerable amount of specie. The officers of the custom-house took immediate measures to recover the valuable cargo, and in a little time the workmen reported the vessel to be nearly covered with sand.

How far the eddying of the water produced by the interruption assists in the formation of the shoal will appear more plainly when considering the effect of interruption and diversion of the tidal current by points of land. The results, so far as the eddying action is concerned, are similar in each case, and it is no doubt safe to say that this condition is the only one under which a deposit can take place in a strong tide-way.

In an inclosed space, like Vineyard Sound, shoals are formed both by the ebb and flood tides; their direction is parallel to the course of the tides, the place from which the material is supplied being situated between them. West Chop affords an instance of this. Its wasted cliffs have contributed to build up the "Hedge Fence" and "Squash Meadow" shoals on the flood, and the long ridge of the "Middle Ground" on the ebb. In bringing forward these particular shoals, however, it is not my purpose to attempt to account for the origin of the materials of all the shoals, but to show, what these cases are especially suited to do, their dependence on the currents.

Although the interior structure of the shoals is not accessible to examination, yet there is every reason to believe, in arguing by analogy from the beaches, cliffs, and hooks, that the sand composing them is deposited in layers, or strata. This is, in fact, the universal law of aqueous deposit. If the views concerning the formation of the shoals here presented be correct, they must have grown up gradually, and a time can be referred to when they did not exist. The rate of their accumulation would depend

upon the quantity of matter transported by the currents, and this again upon the degradation of the land.

The question is often asked, whether the presence of sandy materials in the water is discernible. I do not know how I can answer this question better than by repeating a circumstance related to me by our distinguished fellow-citizen, Mr. T. H. Perkins. About sixty years since he was approaching the coast of New England on his return from the West Indies. By the sudden and unexpected decrease in the depth of water, the vessel was discovered to be in dangerous proximity to the Nantucket South Shoals. The weather was stormy, but the captain found it necessary to carry sail to return again into deep water, and by doing so kept the decks of the vessel washed by the sea. In the morning the decks were covered with the sand which had been lodged there by the waves. The extent to which this part of the ocean is freighted with sand is no doubt always varying, but it may be fairly presumed that a large amount is furnished by every violent storm.

There is no satisfactory means of ascertaining what changes the present shoals have recently undergone. These are probably not important, though undoubtedly increasing. The causes that have produced them, the shoals themselves, and the general form of the shores, have, according to all authentic information, remained in a great measure the same during the historical period of the country.

One quality of the shoals which deserves special notice is their firm and compact structure. That this is not to be attributed to the superincumbent pressure of the water only is shown by the softness of the muddy bottom of the ocean, at the depth of a thousand fathoms. The water permeates so freely through the fine matter of which this is composed, that the upper part of the bottom is partially suspended in it, and thus the water, in resisting, shares the pressure from above. The hardness of the shoals, therefore, must be accounted for partly by the difference of the material, which, being much coarser, is better suited to form a solid structure in the water, and partly, perhaps chiefly, to the beating of the waves, which, hammering with unceasing industry upon their outside, drives the particles of sand closely together, and gives to the whole mass compactness and solidity.

Section II. — *Upon Hooks, Bay-Deposits, Bars, Beaches, &c.*

Shoals are the result of the constructive action of the tides beneath the surface. They do not appear above it on account of their exposed and disconnected situations, and the constant destructive action of the waves upon their summits.

There is another mode of constructive action, which, being finally exhibited partly above water, can be more easily traced in its progress, and which at the same time enables us to form an approximate idea of the rate of increase of the shoals. This mode is founded upon an action of the tidal currents which may be thus explained. A tidal current freighted with suspended matter, and eddying round a bold point, is interrupted and changed in its course by the projecting tongue or prominence at which it turns, and will leave there constantly a part of its burden, this prominence serving as a nucleus to a shoal or bar joined to the land, in the same manner as the inequalities of the bottom to the insulated shoal at sea. The subsequent gradual elevation of the shoal above the water is due to the influence of the winds.

It will be seen by looking at a map of the coast of the United States from the highlands of Navesink to the extremity of Cape Cod, that one normal form is constantly repeated. It is that of a projecting point lying in a generally north and south direction, and inclosing a bay of greater or less extent. That point on the New England coast called Cape Cod being the best known, I will refer to it as the type of this formation, which is repeated in the Great Point of Nantucket, in Cape Poge (Martha's Vineyard), and in Sandy Hook (New York harbour). There are also numerous small points, precisely similar in outline and relation to the local current, to be found in the harbours of this part of the coast. The tide passing along the outer shores, against which it presses with accumulated force, eddies around the extremity of the point, and expands in the inclosed space, where its velocity is lessened by diffusion.

Cape Cod is so large that it can only be examined as a whole on the map; but the small points, in the formation of which the principle is equally illustrated, are easily comprehended in a single view, while something can generally be learned of the rate of their formation from the residents in their neighbourhood.

As the original settlers of New York brought with them from their native alluvial shores the name which they transferred from the *Hoek von Holland* to the sea boundary of New York Bay, and as this name is literally significant of this very common form of alluvial deposit, I adopt the title as a generic term.

The tidal current, as has been said, after passing one of these points, falls into eddies on the inside. These eddies are favorable to an accumulation of the suspended matter, and may also be supposed to control its form. This mode of accumulation is a familiar one to engineers. In the rivers Aar and Rhone, walls projecting into the current are built expressly to obtain a new soil by creating eddies, the sedimentary matter being collected in large quantities by these eddies in one place. It is also understood and practised by our own engineers. At sea-walls and breakwaters the same effect is observed;

and it is a curious illustration of it that lobsters are now found at the breakwater in Delaware Bay, where none existed before, the eddying tides having in the few years that have elapsed since its construction deposited a material suited to their support.* That such deposits are partly above and partly below the water does not impair the efficiency of the cause by which they are produced. They are seen both above and below in the sandy formations of the New England coast, the submerged and exposed positions being continuous and forming a link between islands and shoals.

To return to the general statement: the currents, being interrupted in their course in passing prominent points, are easily deprived of their freights by any unevenness in the ground over which they move. This is so common, that, at every point and headland around which the tides turn, there is a shoal of greater or less extent joined to the land, and making a continuation of the beach. When the site is liable to the destructive violence of storms, the shoal will be small, shifting, and irregular. In the case of those points and capes already cited, which inclose bays, a protection is afforded to the eddies themselves and to the deposits made by them, that leads to certain and continuous increase.

Other circumstances may combine to produce the most favorable conditions under which the hook deposit can be made. If a current freighted with suspended matter has passed in its course over a bottom of regular and unbroken slope, it will, on reaching the point, have parted with but little of its burden. But the current, released from the restraint of the shore against which it presses, commences to turn inward at the place where the eddies created by the point arise, and then the most advantageous conditions of construction will coöperate, and the result will be a tongue or spit of curvilinear shape; that is, a perfect *hook*. This is the manner in which those bays or bights, more or less protected, which are seen on the inner side of each one of the sandy capes, are formed. The accumulation of material is in some cases so rapid as to be easily estimated from time to time. The hook, lengthened by successive additions, and brought to the surface by the tidal deposit, owes its gradual elevation above the water to the action of the winds. They transport materials from the opposite shores, and also drive up the sand that is left dry by the receding tide. These secondary points are sheltered from the destructive action of the waves by their primaries, and on the inner side of the former the protection is still more secure.

The new point of the hook gives rise to its own eddies, the effect of which is finally

* The process of "warping," as practised on the banks of the Humber, exhibits the working in a similar manner of this principle of deposit. — See Mr. Colman's *Agricultural Report*, Part VI.

to deposit on the inside, and near the extremity, a level plateau or flat of sand, as might be expected from the sluggish character of the derivative undulations, which here will have nearly reached a state of quiescence.

If the cape projects far into the sea, like Cape Cod, and incloses a deep bay, a large body of the current which turns to enter the bay at its extremity will pass the first hook and carry the flood towards the lower shores, and thus a new hook may be formed. But as it will not often happen that the circumstances in the second case are the same as those in the first, so the two constructions will differ in outline. One will be complete, like the Bay of Provincetown, and the other a shoal or bank interspersed with islands, like the second formation at Wellfleet Bay. Each one of the capes, Sandy Hook, Cape Poge, Great Point, and Cape Cod, are illustrations, more or less complete, of the hook structure.

We know something of the gradual growth of two of them from early surveys. It appears from a survey made in 1778, that at that date the northern limit of the point of Sandy Hook was about fifteen hundred feet from the old stone light-house. It has since then extended more than three thousand feet to the north and east. In 1778 the main ship-channel ran much nearer the light-house. But at the time of the discovery and settlement we must carry the extreme limit much farther south, bringing it nearer to Horseshoe Bay, where the form from which the name is derived would have been more exactly preserved. Since the preceding date we are able to trace, by surveys made from time to time, the manner and amount of alteration. The point has advanced to the north, spreading out to the east, and losing somewhat of its hook form, owing, no doubt, to the effect of an interruption to the tidal current on the outside, causing there a local excess in the deposit.

Plate III. exhibits the changes in Sandy Hook between 1778 and 1844. Plate II. is a copy of a chart of Cape Cod, by Des Barres, in 1764, from the library of the University at Cambridge. The inner part of the hook is there represented as a shoal. A still more surprising example of increase occurs in the belt called Nausett Beach, which incloses the harbour of Chatham. Captain Franklin Nickerson of Chatham informs me that when he first went to sea, twenty years ago, the common channel-way into Chatham harbour was two miles north of the present opening. The beach-grass is now growing on the site of the old channel. His father, he adds, who died about one year since, remembered when the channel-way was still farther north. The present inclosed basin was then an open harbour, and the inclosure has been made by the gradual extension of the belt to the south.

Great Point (Nantucket) furnishes a striking instance of external deposit. A long

shoal joined to the point extends four miles from the land in an east-northeast direction. An extraordinary supply of the material is brought to this spot by the tides, the first half of the ebb of the Sound conflicting hereabouts with the last half of the flood from the northern shore, and creating lower down a case of what seamen call "tide and half-tide." This shoal is indebted both to the flood and ebb tides for its great extent.

When similar deposits occur at capes and headlands belonging to an earlier geological period, they may come finally to protect the cliffs against further abrasion. Cape Poge is so protected, but West Chop, having no such defence, is, as has been already mentioned, constantly wearing away. It sometimes happens that the continued additions to the extremity of a hook unite it at last to the mainland. A sheet of water is then inclosed, making a lake or pond, breached by heavy gales, which may still have an occasional communication with the sea. Examples of this pond inclosure are common in all that part of the New England coast subject to alluvial deposit. The water in them will in the course of time become fresh, and as the sand continues to be heaped up on the outside of the separating belt (upon which dunes also will rise), their depth often exceeds that of the neighbouring sea. Mr. Lyell speaks of similar formations on the coast of Norfolk, near Yarmouth. Upon the island of Chappaquiddick, adjoining Martha's Vineyard, the people are now employed in converting one of these inclosures into a herring-pond; it is but a very few years ago that it was open to the sea, and has since been made fresh by rain and snow. Opposite to Cape Poge there is another pond nearly closed up, and one individual has undertaken during the last year to complete the work of nature by artificial means, for the same purpose.* This explanation of the manner in which a sheet of water may gradually, and without violence, be changed from salt to brackish, and from brackish to fresh, has, as will be shown hereafter, a peculiar interest in fossil geology.

The *hook deposit* is one of peculiar importance, on account of its form and of its relation to the bay it shelters. It is, however, of inferior importance in its amount either to the *bay deposit* or the *sound deposit*, both which are due to those principles of action of the tidal undulations which are briefly described as follows. The form assumed

* The lake of Stennis in the Orkney Islands "has been actually converted, within a very recent period, whether by elevation of the land or other cause, from a salt-water loch into a fresh-water and marshy tract." —Murchison, *Geology in Russia*, &c., p. 302. Is not this result produced in the manner described in the text? Dr. S. Cabot has stated, in a communication to the Natural History Society of Boston, that there is a pond of water six miles in circuit, called Great Pond, now perfectly fresh, on the eastern end of Long Island, which, thirty years ago, within the remembrance of many living people, was a harbour of refuge for small vessels. This is an authentic case of current action.

by the tide wave upon entering a bay is such, that but a comparatively small part of the body of water brought by the flood impinges upon the point or hook.

The current is carried towards the bottom and sides of the bay, and loses its velocity by degrees as it meets the resistance of the shores. The quiet condition thus produced is the one in which the water drops its burden with facility, and these deposits, to which I have given the name of *bay deposits*, are very large, speaking always comparatively, and follow strictly the contour of the earlier geological structure. In bays of every dimension there will be more or less conflict of the tidal streams, arising from their approaching each other at last from different sides of the bay. This creates an eddying action, which is also conducive to the increase of the deposit, and may perhaps give it a peculiar outline. Besides the formation at the bottom of every large bay, there will be on the inside of every hook a miniature bay also, in which the same conditions of the tidal current are repeated.

This *bay deposit*, then, is generally a skirt of shoal ground, continuous with the beach, and running off some distance under the water, where it is called a bank or shoal. On the inside of the hook, as is seen in the section of Edgartown harbour (Plate II.), the shoal part may be kept quite distinct from the shore by the play of the currents around it, and appear very similar to the isolated ridges formed in the exposed sea. In harbours (which, indeed, are specifically bays) this alluvial structure is never wanting. But in a region of sand the harbours that are found at the bottom of bays owe their existence, in a greater or less degree, to the alluvial deposit. The tidal current after striking the land will follow along its bend, and eddy around any projections that may interrupt its course, depositing a portion of its burden at every tide. The result will be the formation of a hook inclosing a harbour.

The harbour of Barnstable, at the bottom of the bay of Cape Cod, and the harbour of Nantucket, are both examples of this mode of action. The relation of the small hook to the harbour and its deposits is precisely the same as that of the large hook to the bay. The same forms, proportions, circumstances, and positions of deposit, and the same dependence on the local currents, are observed in each case.

These little hooks and their appendages are particularly interesting as a study. Living testimony is frequently obtained concerning their progress, and it is not impossible that an *era of hooks* may hereafter be added to the eras of dunes and deltas. Beach Point (Plate II.) is a beautiful specimen of the small hook, as Cape Cod itself is of the large hook. These two hooks are perfect in form; Great Point and Sandy Hook, on the other hand, are imperfect, the deposit on the outside being so great in the two last as to prevent the full effect of the eddying in giving the curved shape to the inner point or tongue.

Where there is a harbour at the bottom of the bay, as at Nantucket, Edgartown, and New York (the bight included between the Jersey shore and Long Island being considered as a bay with regard to the ocean), a part of the *bay deposit* takes the form of a bar across their entrance. The depth of water on the bar will correspond to the character of the harbour; so, also, will the depth and breadth and directness of the channels, these last being simply the passages kept open by the great body of the water that advances and retires with every successive flood and ebb. If the capacity of the harbour is small, as in the case of Nantucket, the bars will in some places rise near the surface, and the drains or channels will be contracted and narrow, their direction being controlled by the position of the shoals that accumulate near the mouth of the harbour.

If, as at Edgartown, there is a double communication with the sea, and a narrow channel that confines the water and gives rapidity to the current, then a greater depth will be preserved over the bar. And finally, if, as is the case at New York, there is a bay of large capacity, a double communication with the sea, and rivers emptying into the harbour, the depth of the channel over the bar must always be considerable. But the width of the entrance, as well as the capacity of the harbour and the action of rivers, will have a controlling influence upon this depth.

Let us pass for a moment from the harbours and inclosed basins of the North to the peculiar formations of the Southern coast. In Cape Cod, Great Point, Sandy Hook, &c., are exemplified the construction of the external points which shut off from the encroachments of the sea the large bays, under the protection of which are formed the smaller hooks and belts; and these last, as has been seen, may, and finally do, inclose ponds and create harbours. On the southern coast, similar phenomena occur on a large scale, in which the various principles already laid down are brought into play.

There are low borders of sand, forming for many miles the ocean boundary of the Carolinas and Georgia, inclosing lagoons of considerable space and depth, into which the rivers of the continent are discharged. A glance at the map will suffice to perceive the number and peculiarities of these formations.

There is one peculiarity of these inlets, which is, that they have a communication with the sea that is never destroyed, though its place may be changed. In this respect they differ from those in the Vineyard and Nantucket Sounds, which are eventually turned into ponds. Their characteristic feature, however, is, that they are the receptacles of one or more rivers, and that the capacity of each inlet appears to be proportionate to the number and size of the rivers emptying into it. This fact suggests the explanation of their mode of construction and actual condition.

In describing the Northern basins, notice was taken of the manner in which the cur-

rent performs the circuit of a bay, and in which it operates in building up the belt or outer border of the pond or harbour, after the style of a hook. That part of the tidal current which enters the lagoon, and revolves around its inner limit, not only assists this operation, but probably determines the place of the belt, and in some degree its form. Its place must be that of the confluence or meeting of the internal and external currents. When these lagoons are in the process of building up, a ripple upon the extremity of the belt, and beyond it in the line of its direction, indicates the seat of conflict between these two opposing forces. Now, in the case of the great lagoons of the Southern coast, this conflict derives a more distinct and permanent character from the currents of the rivers. There is a more powerful and complete action on the inside, arising from the coöperation of the tidal and river currents, the latter acquiring additional strength on the ebb from their being checked by the flood. The opening to the sea is preserved by the rivers that demand an outlet for their discharge, assisted by the flux and reflux of the tide. Across these openings lie bars of sand, formed, as has been said, by the deposits of the ocean tides, and not by the river deposits, which are wholly dissimilar in mineralogical composition.* The depth of water upon the bar will depend upon the size of the rivers, the capacity of the lagoons, and the rapidity of the tidal or ocean currents. Therefore, under favorable circumstances, the bar might, in the case of the Southern lagoons, as of the Northern ponds, rise to the surface, and, by completing the belt, break off the communication with the sea. The streams would discharge themselves into a lagoon thus inclosed as into a lake, and change them from salt to fresh water. Finally, the lagoon might be filled up by the river deposits, and a soil be accumulated suitable for tillage, even below the surface of the sea. Mr. Lyell's similar cases may be again referred to. (*Principles of Geology.*)

By these successive changes a home is created for animals of salt, brackish, and fresh water, in the same spot, where their remains may be found buried together; as they are now in the tertiary basins of Paris and London. The principle of confluence is illustrated wherever two moving streams of water meet, whether they belong to the ocean or to an inland sea, to tides or to rivers, or to both combined.

An instance of an imperfect lagoon formation, of classical celebrity, is that of Venice. The *lidi* are belts resulting from the confluence of the gulf and river waters. At the meeting of the Rhone and Arve a similar deposit in ridges is formed. In the beds of the small rivers that empty into the harbour of Boston the same results are produced, though here, of course, the influence of the tidal currents predominates. The shoals

* Professor H. D. Rogers has shown that these formations are caused by the meeting of the rivers with an external current. But he considers the Gulf Stream as the external current.

in our great estuaries, the Delaware and Chesapeake Bays, must be attributed to the confluent action of the tides.

The normal currents of the ocean may, however, take the place of the tidal currents, and exhibit the same effects. The constant current flowing into the Mediterranean Sea may be cited as a striking example. At the Rock of Gibraltar this current divides into two branches, one of which enters the Bay of Gibraltar, while the other passes to the eastward of the Rock; and the conflicting action of these two streams has built up the long and narrow ridge of sand, known by the name of the Neutral Ground, that unites the fortress to the Spanish peninsula. The large bank to the eastward of this ridge is an instance of *bay deposit*. In the Nehrungen of the Baltic, the external current is probably one that is caused by the prevailing winds. I have no doubt that these formations are to be accounted for in the same manner as all similar phenomena, but am not sufficiently well informed concerning the currents of the Baltic to speak of them in detail. Bars or belts of the same kind are found at the mouths of the rivers emptying into Lake Superior, and on the south shore they are so long that the river stream runs parallel to the land for some distance. These belts follow a constant direction, different on different sides of the lake, determined, no doubt, by the currents caused by the prevailing winds and by changes in the atmospheric pressure.

It follows from what has been said, that there are three distinct conditions under which the formation of belts and lagoons may take place. They may be the product of tides only, of which the currents act internally and externally, as in the ponds and small harbours, or partially inclosed basins, of Nantucket and Martha's Vineyard. They will occur on a much larger scale where the tidal action is assisted by rivers, as in the sounds and inlets of the Southern coast. And finally, the absence of a regular tide-stream may be supplied by a normal current, as at Gibraltar and in the Baltic. In all cases the direction of the belts is closely allied to that of the coast, being in general a little convex towards that quarter from which the external current approaches. When the tide is small, and the river rapid and loaded with matter, there is a strong tendency to fill up the lagoons and transform them into swamps. Large and muddy rivers penetrate beyond the sea-border and build up that form of deposit called deltas. The deltas, accordingly, are never surrounded by belts, like lagoons; and as these belts are produced by external currents, it follows that there can be no strong tidal or uniform ocean current where there is a delta. At the mouths of all those rivers most distinguished for their deltas, as the Mississippi, the Nile, the Po, the Rhone, and the Orinoco, there is little or no tide.

While, on the other hand, there are tides of a marked and decided character at the

mouths of other rivers equally strong and muddy in their currents, and magnificent in their dimensions, but having no delta deposits; as the Canton, the Guayaquil, the Amazon,* the Paraguay and others emptying into the Rio de la Plata, the rivers of Western Europe, and all the rivers on the eastern coast of North America, north of Florida.

Not only are deltas wanting where there are strong tides, but the mouths of the rivers affected by the tidal currents branch out into wide bays or estuaries filled with shoals composed of materials brought by the ocean (in our country quartzose sand), while the greater part of the river matter is carried off through the channels leading into the sea, owing to its lightness, and to the rapidity of the reflux caused by the retention of the river streams during the flood tide.

The conclusion, then, is drawn from these views of constructive action, that tides and delta deposits are incompatible with each other; that where there is a regular tidal or normal current of any consequence there can be no delta formed, and that such a current will always be a characteristic feature of those wide bays and river outlets where deltas do not exist. This fact of the absence of deltas where there are regular tides is distinctly stated by M. de la Bêche in his "Manual," who accounts for the apparent exception in the case of the River Ganges by remarking that the formation of the delta occurs in the rainy season, when the outward flow of the river is constant, overcoming the current of the flood tide, and keeping the water fresh for many miles at sea.

The most common and the best known of all the forms of ocean deposit remains to be noticed; that is, *beaches*. This term is applied indifferently to the borders of seas and lakes composed of loose materials, whatever that material may be. Where there is tide, it defines particularly the space included between low water and the highest reach of the tides. Beaches of sand line the whole coast of the United States, from Florida to the northern extremity of Cape Cod, sand being the material of which this part of our coast is exclusively composed. And here every variety of form and condition of beach is to be met with. If the shores are washed away by the destructive action of the waves, and its materials taken off by the currents, the beach marks the present limit of alteration. This is the case at the southeast part of Martha's Vineyard, where one mile in breadth of beach has disappeared in fifty years.

* The effect of the equatorial current (passing Cape St. Roque) is to take off to the north and west the solid matter brought down by the Amazon, and deposit it along the shore of French Guiana, or in the adjacent sea, which it has made shallow to the distance of several leagues from this coast. I have not overlooked this, and the remarkable character of the tides of the Amazon, nor the irregularities resulting from the conflict of the tidal and equatorial currents.

If, on the contrary, the shore is gaining, the beach shows the extent of the constructive process. The growth of Nausett Beach, already cited, is an example.

In some places the changes are irregular, as at Siasconsett, the southeast part of Nantucket. There is now but a narrow strip of beach between the cliff and the sea, where, between 1778 and 1792, the beach spread so much that the fishermen dried their fish upon it. The changes both of gain and loss are reported to have been gradual, and were no doubt connected with corresponding changes elsewhere.

The plastic power of water over so impressible a material gives to all sand beaches a general resemblance. It is impossible, therefore, to distinguish between those that are the remains of former shores, and those that are constantly increasing, without a knowledge of local facts and circumstances, such as may be frequently obtained from the neighbouring inhabitants. When *hooks* are united to the mainland, they become beaches. The same term is given to those necks of loose material which join islands with each other, or with the mainland, and which result from the confluence of two currents approaching from opposite directions. The beach of Nahant is built up in this manner, by the meeting of the two branches of the flood tide, one entering to the north and the other to the south of Nahant Head, at which the stream of the flood is divided. The "Neutral Ground" at Gibraltar has been already mentioned. The effect of this mode of construction is to change the geographical character of the place at which it occurs, by converting two or more islands into one, or an island into a promontory.

According to the principles laid down in this memoir, beaches should be found wherever there is a tidal or normal current. And it is so. Even on rocky coasts, where the tides are very rapid, the ocean deposits are made at the bottom of bays and in the indentations of the shores, the tidal currents losing in these situations their velocity, and turning easily into eddies. Phillips's Beach and Chelsea Beach are examples of this kind of bay deposit; but the rapidity of the currents and the exposure to the sea have prevented the beach formation on the projecting points of rock which inclose these bays, except in very sheltered spots.

Beaches are constantly undergoing changes, and these changes are likely to be extensive and important in proportion to the abundance of the material. They have always attracted much attention, especially where, as in Holland, the alluvial formations have exercised a real and permanent influence upon the public economy. It is these changes alone that have been treated by the geologists, who, overrating their individual consequence, have lost sight of the fact that they are merely the present indications of the modes and periods of great operations which have produced much grander results. The destructive agency of the waves upon them has been carefully studied, but the principles of their formation appear to have been wholly overlooked.

The action of the waves upon beaches creates the ribbed surface, the curvilinear outline, and apparent stratification which they exhibit. The light sea-weed, carried to the highest reach of the tide, gathers about it and along its extent the sand that is transported, either by the water or the wind. The curved lines follow the natural form of the summit of the wave; and the ribbed surface is an alternation of small sand-ridges and pebbly hollows, attributable to the abrasion of the latter, rolling back in a heap with the receding motion of the wave.

But the most noted and interesting effect of waves is the ripple-mark, seen upon the beaches of lakes as well as of the sea. It is produced under water by that slight agitation of the surface from which it takes its name, and is most conspicuous, perhaps, in beaches of long and gentle slope. Shores of this description are common to lakes, where, accordingly, the ripple-mark is abundantly displayed.* But the beaches of the sea are very irregular and various in declivity in the region of tides, as might be expected from the deposits which it is their office to make; and the same portions of the shores are alternately covered and exposed as the tides flow and ebb. Ripple-marks, therefore, will not be distributed over the beaches of the sea as uniformly as over those of lakes. Being similar in both instances, they must be distinguished from each other in the earlier geological periods by geographical positions. The ripple-mark is visible on the surface of many sandstone deposits, and may be taken, according to Mr. Agassiz, as a guide for estimating the early action of the moon upon the earth's surface, by means of the tidal motions.

In many places the sea-beaches are covered with longitudinal ridges of coarse gravel, pebbles, and stones, rising sometimes to a considerable height, lying parallel to the course of the shore, and following its sinuosities. A very interesting example of this is presented in Chelsea Beach, in Boston harbour. The ridge begins at the entrance of the bay, where it attains the greatest height, and where the stones, unmixed with gravel or sand, are of the largest size. The height and the size of the stones diminish gradually towards the bottom of the bay, until the pile terminates in a small ridge of gravel and sand, without stones. This phenomenon results from the combined action of waves and currents. At the upper part of the beach, there are high cliffs of coarse drift, which are washed and undermined by the sea, and their debris is carried away by the tidal currents in the direction of the flood, that is, towards the upper part of the beach. During violent storms, to which the beach is exposed, the coarse materials are projected upon the shore

* As the memoir and chart of M. A. Guyot have made us intimately acquainted with the lake of Neufchatel, I will adduce the southern shore of that lake as an obvious example.

by the waves beyond the reach of common tides, and, there heaped up, they form a natural sea-wall defending a tract of meadow land from the encroachments of the water. The structure of the wall on the land side affords a striking evidence of the projectile force of the waves. Owing to some causes that give them a greater violence in certain directions, they have so crowded up the stones that in some places they stand like abutments to the inside wall. But the part performed by the waves is merely to accumulate the materials in masses. It is the currents that transport the materials in their course, and decide their position; the best proof of this is the fact, that on the opposite side of the cliff there is no sea-wall, although there the action of the storm is equally felt. It might be objected, that the tidal currents are incapable of moving such heavy weights; but, besides the proofs afforded by the relative positions of the wall and cliffs, some facts will be brought forward hereafter which will remove this objection. It has been suggested, and I have no doubt correctly, that the kelp on the rocks assists the action of the currents by the large and buoyant surface it presents to their force. M. Elie de Beaumont has described the appearance of several similar formations; one, particularly, at Dieppe. In that instance, also, the source of the materials which form the sea-wall (*levée de galets*) is situated on that side from which the flood tide approaches. The tide rises to a greater height here than in Boston harbour, and the stones are transported by the current with such facility and in such abundance, that it has been found requisite to construct artificial walls, and contrive a plan for washing the channel by the river, in order to keep open the port.

It follows, therefore, that these sea-walls, though owing their actual form to the waves that keep the materials on the shore, owe equally their position to the currents, which, transporting the materials from the place where they have fallen into the sea, bring them where they will be subject to the action of the waves in storms.

When the beach is composed of light, silicious sand, easily transported by the wind, the phenomenon of *dunes* or *downs* appears. They are hills consisting altogether of light particles of sand, deposited by the tide, which, being exposed at low water, dries, and is blown up above the reach of the sea. The dune formations are immediately known by their peculiar figure. The top is smooth and rounded, sloping gently towards the quarter from which the sand comes, and steep and irregular on the opposite side. They are, however, too well known to require a particular description here, though they are so prominent a feature of a sandy region, that it would not be proper to pass them over entirely. M. de Beaumont has given the fullest details concerning their rise and progress, showing how they advance by successive steps into the interior, render sterile the soil which they invade, and overwhelm villages in their path. Sometimes, indeed,

they prove beneficial, by lining the inner border of the beach with a range of low hills that guard the land within from the inroads of the sea, or by fencing around a low cavity of water, which, being first converted into a swamp, becomes finally the only fertile ground of the region. But the surface of every alluvial soil is a dune formation. Capes, hooks, beaches, &c., owe their growth above water principally to this cause, and where the spot is favorably situated for such mode of accumulation the rate of increase can be satisfactorily estimated. Dunes, in common with deltas, accordingly have been employed as a *geological chronometer* for determining the periods of the actual alluvial formations. In Europe the phenomena of dunes are more extensively developed than in the United States. At Cape Cod, however, they exist in every variety and of the greatest size, and have formed with such rapidity, that the inhabitants of Provincetown, fearing to be buried in their progress, have planted great quantities of the beach-grass (*Calamagrostis arenaria*) on the northeast end of the cape for protection. This pioneer grass readily takes root, and lays the basis for vegetation.

One cause why the dune formation is less general in the United States is the absence of any great level country of sand, like Holland or the Landes of France. The chief reason is the hilly and unequal surface of that part of the coast in which the deposit is made. The sand is frequently deposited at the bottom of high cliffs, as at Martha's Vineyard and Nantucket, up which it is blown with such violence, in strong winds, that it is necessary to cover the face to secure it against injury. Upon the surface of the cliff, which it renders sterile by its constant additions, it is dispersed equally by the wind in level beds, following the form of the stratum on which it lies, and is not heaped up in the dune shape, as on the more level parts of the islands, and where the cliffs are low.

At Sankaty cliff, on the southeast part of Nantucket, there is a deposit of this loose sand, two and a half feet thick, covering the former soil. At the edge of the cliff, where it has been washed away, it is seen that this loose sand has covered swamps, which, having been drained by the destruction of the cliff, are converted into beds of dry peat. This deposit of sand must have begun after the wood, that once covered the island of Nantucket, was cut down. Its rate of increase, therefore, might be estimated. The wind deposit is distinguished from the water deposit by three peculiarities; — it follows the form of the stratum on which it lies, it is not stratified, and it contains no pebbles. At Cape Cod the ripple-mark made by the wind occurs frequently, and in several spots that are particularly liable to its action, the pressure of violent gales has produced a hardness of surface similar to that of the shoals, resulting from the action of the water.

Section III. — *Geographical Distribution.*

The preceding pages of this memoir have been devoted to a description of the various forms of ocean deposit, and to a statement of the mode of connection between those forms and the tidal currents from which they are derived. Hitherto I have confined my inquiries to the shores of the United States, and particularly to the coast of New England, because there the various results of constructive and destructive action were under immediate observation, the nature of the tidal currents was well known, and local information concerning recent changes has been most readily obtained. The next step is the application of the natural laws deducible from these investigations to similar formations on this continent and in other parts of the world. Before entering, however, into the subject of geographical distribution, it is necessary to lay down one principle of tidal deposit which has not yet been distinctly enunciated. It is this, that deposits upon the *ocean border* are only made by the current of the *flood* tide.

In the *sounds* and *bays*, the *ebb* tide may also leave its burden, since in its retreat it may not only meet with obstructions, but must press upon the land, in some parts, precisely as the advancing flood does upon the exterior coast. In a group like the Nantucket Shoals, the ebb, carrying with it the sand that has been loosened on the shore, and being hindered in its course by the inequalities of the bottom, must also contribute to build up the deposits. These cases are not alleged as exceptions to a law, but are stated as modifications merely, through which the action of the ebb is brought to resemble that of the flood. In general, as the deposit of the flood is made on the shore in the direction of its progress, so the deposit of the ebb is buried in the bosom of the ocean. The former furnishes the material for the alluvial deposit above water; the latter supplies the substances found in the depths of the sea.

It is not meant to say by this, that the action of the flood and ebb tides is reciprocal. On the contrary, the mode of operation of the flood is essentially cumulative. Its tendency, also, is to continually carry onward the deposit, in the course of its current, so that it performs the double office of increasing the collection at every successive tide, and of advancing from place to place the matter at its disposal. This double process is exemplified by the manner in which the materials of wrecks are conveyed along the shore in the direction of the flood at that place. I have previously said, that the course of the flood current on the outside of the island of Nantucket is from west to east on the south shore, and turning with the trend of the land from south to north on the east shore. A few years since, the British bark The Earl of Eglintoun was wrecked on the south side of the island of Nantucket, two miles east of the meridian of the town. Her

cargo consisted in part of coal, great quantities of which were carried round the island to the eastward and northward, and picked up on the inside of Great Point. The keeper of the light-house at Great Point supplied himself with fuel for the winter from this source. The brig Packet, of Providence, was also wrecked on the south side, opposite the town; and pieces and bales of duck and diaper were found along the beach to the north of Sankaty Head. The coal of a Philadelphia vessel, lost at the western end of the island a long time ago, was also carried round in the same way, and deposited at Great Point, the northern extremity of the island. In 1812, the English ship Queen, a prize to the privateer General Armstrong, was stranded, with her prize crew on board, on the south side, and, as it is supposed, at Miacomet Rip. Her cargo was strewed from the Rip, eastward and northward, to the end of Great Point. A chimney is now standing in the village of Siasconsett built of bricks from her cargo that were taken up in that vicinity, and some of the bricks were found about a year afterwards on the inside of Great Point, their edges rounded and smoothed by the action of the water. The bricks were known by their uncommon size. In none of these instances were any of the wrecked materials seen to the westward of the spot where they first struck the island, that is, in the direction of the ebb. This is well known to be universally the case, so that the wreckers never go to the westward, but always to the eastward, to search for floating articles. The fact is the more striking, that this course is opposed to the violent northeast gales, the principal cause of loss to shipping. For the preceding details I am indebted to Mr. Mitchell of Nantucket, the astronomer, to Mr. Rand, the collector of the port, and to Captain Rand, the father of the latter gentleman, a highly reputable and intelligent shipmaster.

But the characteristic action of the flood may be observed with even greater distinctness on the eastern shore of Cape Cod. There is a separation or split of the tides that takes place about six miles south of Nausett lights, and nine miles north of Chatham. The tide-wave divides in this vicinity, the current of the flood running north on that part of the cape shore which is north, and south on the southern side of the separation. At the place of separation the tide-currents appear to run towards and from the land, or, in the technical phrase, on and off shore. Now the materials of vessels that are wrecked to the southward of the seat of division of the tides are uniformly carried south, and are frequently found inside of Chatham (new) harbour, or of Monomoy Point; while, on the other hand, vessels that are wrecked so far northward as to be within the reach of the northern current of the flood have their effects scattered along the north shore, and, making occasionally the entire circuit of Cape Cod, are even deposited in Provincetown harbour. Here, as I am informed, this distinct action of the two currents of the flood

tide is so well understood, that those persons who search for the property of stranded vessels never go to the northward of the wreck when it lies to the south of the point of separation, or to the southward when it lies to the north of it. And in this latter case the movement is, as at Nantucket, opposite to the prevailing winds. The transportation of such heavy materials as coal and bricks has been mentioned. Mr. Small, the keeper of the light at Truro, from whom I have received much valuable information, communicated another curious instance of the power of the current in moving heavy articles. A brig of two hundred tons was stranded near Truro, and three weeks afterwards Mr. Small picked up her anchor, which had some ten fathoms of chain cable attached to it, about one and a half miles to the northward of the wreck. The anchor advanced, probably, by being turned over and over, the force of the water acting chiefly on the large surface of the stock; and the chain was dragged after. This illustrates the manner in which the kelp on the rocks at Chelsea Beach may be supposed to facilitate their transportation. Mr. Small also said, that, when articles float light upon the water, and offer a large body to the resistance of the wind, they may, during the violence of the storm, be carried against the current. During seven eighths of the time, to use the expression of Mr. Small, the waves break on the shore at Truro in a direction to the northward of west, the shore itself running north and south. This takes place in opposition to northerly winds. If these winds are exceedingly strong, they may for a short time overcome this prevailing tendency; but as soon as the strength of the gale abates, the waves resume their ordinary course. It is the same on the eastern shore of Sandy Hook and of Nantucket, as I have myself observed. As the flood tide runs in a northerly direction at each of these places, the idea is suggested that there is an intimate connection between the course of the current and the manner of approach of the waves to the beach; and if, upon further examination, this should prove to be the case, then the wave and current actions combine to produce the same effect, and we shall be less surprised at the transportation of heavy materials along the coast.

The constructive process of the flood is equally exhibited in the way in which the hooks, &c., are built up. They extend and increase always in the direction of the advancing current; as, for example, the Great Point of Nantucket gains constantly to the north, and the Point of Monomoy to the south, which are the directions of the flood currents at these two places respectively. And so with all the hooks, both great and small, of the northeastern coast, whether formed on the borders of the sea, or in inclosed bays and harbours.

To return to geographical distribution. The shores of the United States, from Florida to Maine, so far as alluvial deposits form the ocean border, exhibit similar features both

in outline and composition. In these respects there is a striking uniformity in the coast, while in the interior the geological diversities allow a wide range of dissimilarity. The keys and banks of the Florida coast, in which the deposit of sand is mixed with that of the coralline detritus, are to be considered on another occasion. Beginning, then, from the southern extremity of Georgia, and proceeding northward, there is a belt, of variable breadth and of loose material, the leading distinction of which is that it has been for a long time subjected to the action of water. This quality is so prominent as to create a uniformity of appearance independent of mineralogical composition, showing that it is the mechanical, rather than the chemical, properties which give the predominant character to these formations. A part of these alluvial deposits is formed and remains under water, as, for example, the Nantucket Shoals. But there are also, at a distance from the American continent, towards the northeast, very large subaqueous deposits, as George's, Newfoundland, and other banks, resembling the banks and shoals near the coast in structure and material, to which we are naturally led to apply the same laws of origin and formation. The idea of such a connection is not controverted by the distance apart, and apparently distinct separation, of the great banks; for the smaller banks and shoals near the land are divided by valleys of proportionate depth, having for their bottom mud, gravel, and large drift, teeming with animal life, in which the shoals themselves are wholly deficient.

Taking the whole of these sandy formations in one view, and considering them in relation to the continent, it will be remarked that a comparatively narrow and compact apex at the south spreads towards the north and east into a broadly diffused and unconnected series of deposits, and that throughout this extent all the minor varieties of geographical division are met with. But the greatest amount of the material is collected at the north and east, in which direction it seems to have been carried as to a place of final rest. A line traced with a free hand through this space will be the arc of a quadrant nearly, the abscissa being somewhat longer than the ordinate, and this upon examination proves to be the general course of the tide-wave on this continent. The effect of that undulation which rises in the Bay of Fundy will be noticed subsequently.

The progress of the great tidal wave of the Atlantic is from south to north; the cotidal lines, or lines representing the summit or ridge of the tide-wave, drawn between places on both sides of the ocean that have high water at the same time, being (speaking in general) at right angles to the meridians. These lines are curves, convex in the direction of their motion, in consequence of the retardation of their extremities by the shores of the continents. The effect of this retardation is to create those numerous tidal currents, and various conditions of rise and fall, of conflict and interference, which

constitute the *tides*, as they are spoken of in popular language, and known to the common observer. But the retarding influence will first be felt at the outer bank, or line of soundings, that marks the approach to the coast of the United States, and the result will be an early diversion of the tide-wave from its regular course, altogether independent of the local peculiarities occasioned by its subsequent collision with the diversities of the shore itself.

As the tide-wave, then, advances along the eastern border of this continent, it will be deflected to the east by the obstacles it encounters in its progress towards the coast of New England and the British possessions, until, passing the eastern limit of opposition at Newfoundland, its regular course is resumed. This statement is partially made in the first section of this memoir, where the conformation of the Nantucket Shoals is described, and their relation to the tidal currents defined. The Nantucket Shoals, being formed in the sea, have a closer affinity to the great banks than the hooks or bay-deposits, which are due to tidal currents that are specifically local. By enlarging the bounds of the reasoning applied to the former, we should expect to find those great sand deposits, George's, Sable Island, Banquereau, Green, Whale, and Newfoundland Banks, in the very positions they occupy, that is, in the path of the general tide-wave that washes the shores of the continent, modified as it is by the obstacles to its regular course.

It has already been assumed, that there is probably a nucleus which determines the precise locality of a subaqueous deposit, and that its amount and form depend upon the condition of the water as to motion or rest when it takes place. But I will also venture to suggest, that further investigations into the tidal currents of this part of the ocean may disclose a meeting of the tides at each of the two great banks of George and Newfoundland, perhaps from the confluence of the regular tide-wave of the Atlantic with the divergent wave from the American coast, the two waves belonging of course to different epochs. This view is supported by the motions of the tidal currents. They go entirely round the compass in every successive ebb and flood at both of these places. On George's Bank, according to the excellent survey of Captain Wilkes, the main body of the flood sets to the northward and westward, and changes from that to the eastward of north; and this change may be caused by a conflicting current from the coast. The prevailing opinion that there is a southerly and westerly current along the east and south coasts of Newfoundland indicates, in connection with the circular motion of the tidal currents on the Grand Bank, that a similar conflict may exist here also. On the southern coast of Nova Scotia, the establishments between Cape Sable and Cape Canso vary about one hour in time, being most early at the west. From this it appears that the tide-wave approaches this coast at right angles to its line of direction.

It is, moreover, to be observed, that George's Bank, the first in order from the coast, is situated remote from the land, and below the opening of the Bay of Fundy. In this free space the force of the current is weakened by diffusion. The banks lying to the southward of Nova Scotia and Newfoundland, where the velocity of the current is restored by the pressure of the tide upon the neighbouring coast, are comparatively long and narrow.

At the Grand Bank, the open ocean must again deprive the tidal currents of any character or force, except that derived from the obstructions of the bank itself, and there the diffusive deposit occurs for the last time, (except at the small Outer Bank, which is very indicative of a nucleus,) and on a much grander scale. Finally, the current that makes a circuit round the southeast extremity of the island terminates the bank of Newfoundland on the north in an elongated end, following somewhat the trend of the shore. Such at least is the form marked on the nautical charts.

If, again, after passing Cape Cod, we pursue the course of that undulation which supplies the coasts of Maine and the Bay of Fundy, we meet the two banks called Cashe's Ledge, and Jeffries' Bank, both of which are long and narrow. They lie in the region of rapid currents, which, as has been previously said, induce this form in constructive deposits.

Assuming the fact, that, in general, the strength of the current bears a direct ratio to the rise and fall of the tide,* it will be interesting to inquire into the range of the tide in those places where the ocean deposits exist. And from this inquiry it will appear, (not forgetting the importance to be attached to the inequalities of the bottom,) that the amount of the deposits everywhere holds a subordinate relation to the rise and fall of the tide.

In Delaware Bay, along the Jersey coast, at Sandy Hook, and in New York harbour, the range of the tide varies between five and six feet. In the Vineyard and Nantucket Sounds, where the shoal formations abound, it rises between two and four feet, being quite irregular in its motions, in its rise and fall, and in some places in its times, on account of the frequent interferences which, in these inland waters, arise from numerous communications with the sea. On the Nantucket Shoals the tides rise to the height of five feet.

At the southeast part of Cape Cod, that is, the north part of Nantucket Sound, the range of the tide is very small, and, as I have already noticed, a convergence takes place

* This statement is made without losing sight of the effect of retardation and accumulation at headlands, points, shoals, &c., which is to produce great rapidity of current in those places, even where the range of the tide is small.

here of the tidal streams coming in opposite directions from Nausett Beach towards the south, and from the island of Nantucket towards the north. This convergence is immediately suggested by the fact, that, if a vessel grounds on the *south* side of one of the shoals in this vicinity whilst the tide is running ebb, she will begin to float on the last quarter of the ebb current. The shoal formations are numerous and extensive here, and, according to the information given me by the inhabitants, accumulate rapidly in favorable situations. Dry Shoal is a name given to one of them that has appeared above water within a few years in a protected part of the bay formed by Monomoy Beach, and opposite to the opening into Chatham "New Harbour." There are no shoals on the Cape Cod shore north of Nausett, though some bars are deposited at the point of the cape. At Cape Cod the tide rises ten feet. On the coast of Maine the tide rises from ten to eighteen feet, being greatest at the north; and in the Bay of Fundy it rises to the extraordinary height of sixty feet. On the coast of Maine and in the Bay of Fundy there are no shoals.

On the Atlantic south coast of Nova Scotia, which is lined with banks at some distance from it, the average range of the tide descends again to eight and six feet. Upon George's Bank the tide rises seven feet, and though but little is known of the tides of the open ocean, yet it may be safely assumed that at Newfoundland Bank the range is not great. In all the cases cited above, there is an observable proportion between the tides and the aqueous deposits, the amount of the latter being more, as the height, &c., of the former is less.

This reasoning does not imply that shoals should be found wherever the character of the tide is suitable for their formation. A proportion must also exist between the amount of deposit and the quantity of loose material; and it is perhaps to the deficiency of the latter that we are to ascribe the absence of shoals on certain parts of the western coasts of this continent.

Passing from the shores of America to those of Europe, we there find deposits of sand of remarkable extent, giving the same character to navigation as here, and constituting, in one instance, the residence of a people distinguished in arts and commerce, whose national economy derives a peculiar stamp from the nature of the soil they inhabit. Holland is the most interesting, in many respects, of all similar formations. It is situated on the southeast corner of the German Ocean, where the tide-waves that enter through the Straits of Dover are met and repelled by those which, making the circuit of the British isles, return again from the north. This convergence of conflicting currents is the condition already specified as the one the most favorable to a large deposit. The narrowness of the English Channel, by creating rapid currents, forbids deposits there.

except in those small bights and bays where the water becomes still, or expends its force in eddies. But when, after passing the Channel, the sea expands, the circumstances are again suited to the deposition of its burden, especially on the side concave to its axis, or, in other words, having the bay form; which is the situs of the Netherlands and the peninsula of Jutland.

The convergence of the tide-waves in the North Sea and English Channel is a very conspicuous feature of this region. Professor Whewell, from whose valuable *Researches on the Tides* I have received much assistance, has endeavoured to "combine all the facts into a consistent scheme by dividing this ocean into two *rotatory* systems of tide-waves: one occupying the space from Norfolk and Holland to Norway, and the other the space between the Netherlands and England." On the coast of Jutland there is a vanishing point of the tide which he endeavours to explain by the motions of the former system.

Throughout this region there is a correspondence between the height of the tide on the one hand, and the form of the land and amount of the deposits on the other. The greatest range of the tide between Brest and Dunkirk varies from thirty to sixteen feet. But after passing the narrow limits of the Channel, it descends, in proceeding along the coast of the Netherlands, to nine, six, and three feet. Finally, on the north of Jutland, the tide ceases to rise altogether; a state of perfect uniformity is produced by the conflicting currents.

In this conflict of the tide-waves coming from the north with those advancing through the British Channel, by which the latter are forced over upon the eastern shore, retarded in their progress, and finally repelled; in these rotary systems or eddies upon a grand scale of the tidal currents; in the bay form of the shore; and in the gradually decreasing height of the tide taken as an exponent of its strength, we have a combination of all the circumstances most favorable to alluvial and subaqueous deposits. Accordingly, not only have the sandy regions of the Netherlands, raised above the water by atmospheric influences, been accumulated, but the North Sea also abounds in shoal formations of every description. This is the grand depot of the loose material on the eastern coast, to which it has been transported by successive degrees, and in which it has been confined by the double action of the tides. To apply in detail to the various forms of deposit, common here as well as on the American coast, the reasoning contained in the first and second sections of this memoir, would be, even if I could trust to my imperfect knowledge of the local currents to attempt it, merely to repeat what has been already said. But the object in this section is the development of general principles, and not the explanation of particular cases.

But I must allude in passing to two other instances of alluvial deposit, one on the

coast of Norfolk and Suffolk; the other, on the southern shores of Norway. The first of these instances occurs at the meeting of tides arriving in opposite directions along two different channels, and this meeting is pointed out by the crowding together of the co-tidal lines, or, in other words, by the rapid change in the tide-hours due to the impeded progress of the tide-wave. Between Yarmouth and Southwold, the least range of the tide is two or three feet, while the greatest range is only seven or eight feet. But at points on each side of these stations, and not far distant from them, the greatest range of the tide rises to twenty feet. (See Whewell's *Researches on the Tides*, Sixth Series.) The changes that have taken place on this part of the English coast have been described in detail by Sir Charles Lyell, and M. Beaumont. It is not necessary to repeat here what has been said concerning them, but it must be admitted that they support in a satisfactory manner the view that the amount and locality of alluvial deposits are in certain cases determined by the interference or convergence of opposing tide-waves, and dependent in a measure also upon the motion of the tidal currents, of which the average rise and fall of the tides may be taken as an exponent.

The subaqueous deposits, or banks, off Yarmouth result from the same causes. The alluvial formation in the Wash is an instance of *bay deposit.*

With regard to the sandy region on the southern coast of Norway, of which Christiansand is the principal depot, it is to be observed that Stavanger is a point of divergence, from which one portion of the divided tide-wave travels sluggishly along the south shore, until, at Christiansand, the greatest range of the tide is only one foot. It is a probable inference from the principles laid down, that the deposit in this region is owing to the conflict of the feeble tidal current corresponding to this tide-wave with the constant current that flows out of the Baltic.

This current always sets to the westward along the shore, but its force must be gradually overcome by the pressure of the tidal current, which becomes more sensible as it proceeds to the westward. It is further to be remarked, that the currents created by the winds on the southwest coast of Norway run much stronger to the south than they ever do to the north.

The Landes of France, at the bottom of the Bay of Biscay, is another region of sand too well known to geologists to need description. It is an instance of the *bay deposit* on a large scale, as Holland is of the *sound deposit.* It lies in the place to which the material should be carried by the tide, which, turning round Cape Ortegal, makes the circuit of a great bay. The original form of the bay, at the beginning of the present era, was deep and pointed towards the bottom, and thus particularly suited to create numerous interferences resulting in eddies, and in that state of rest in which the water readily drops its freight.

Here, again, the course of the tide-wave is favorable to an extreme accumulation. There is a point of divergence between Santander and Bilboa, and the undulation which passed on into the bottom of the bay must have been overtaken, and opposed on its turning to the north, by the succeeding tide-wave, particularly in the early epoch of this formation, before the bay was filled up as at present, and while the tide-wave would occupy a longer time in its transit. At Santander and Bilboa, the average height of the tide is nine or ten feet. I have no means of ascertaining what it is at the bottom of the bay.

The similarity in effect of the *normal* currents of the ocean, when they strike the land, to the currents of the tides, is displayed in the general as well as the local deposits. The deposit in the Mediterranean has been mentioned.

Another striking example occurs in the Gulf of Mexico. There is a current which, entering by Yucatan, makes a circuit of the coasts of Mexico, Texas, Louisiana, &c., and finally becomes a tributary to the Gulf Stream.

In the Bay of Campeachy there is a large bay deposit, and the shores of the Gulf on the west and north (interrupted only by the deltas of the Mississippi) are altogether alluvial, being composed of the same loose material as those of the Atlantic border of the United States. M. Elie de Beaumont has dwelt with some particularity upon the description of the Gulf coast.

But the western coast of Peru affords, perhaps, the most interesting illustration of the effect produced by the action of a constant ocean current. There is an antarctic current which strikes the western coast of South America to the northward of the island of Chiloe, and, pressing against the shores, follows their course up to the parallel of four and a half degrees south, or the southern entrance of the estuary of Guayaquil, when it turns off towards the Galapagos Islands. On the Peruvian coast there is a zone or belt of sand, two thousand miles in length, and varying in breadth from seven to fifty miles. The greater part of this sand is heaped up by gradual accumulation, according to the law of constant transport from place to place, at the northern part of Peru, the terminus of the connection between the current and the land. In this region it has created the desert of Pachira. The rise of the tides in the River Guayaquil is six feet, which has given birth to an estuary, the southern shore of which is sandy. This shore is the place of meeting (against the land) of the ocean and tidal currents.

As the form of the eastern coast of North America coincides with the general direction of the Gulf Stream, it may be suggested that we are to look to that as one of the causes to which this form is due. The effect of the Gulf Stream as a normal current of the ocean, where it actually impinges upon the extreme southern portion of the coast

of the United States, has been considered. The power it may exert in carrying forward the tidal undulation while it is passing through it, and thus in affecting the condition of the coast, is worthy of inquiry. But in this memoir the forms, localities, and amounts of the alluvial deposits have been attributed to the active influence of local currents; the same reasonings could not be applied to the Gulf Stream, which only touches the land in the beginning of its course. So far as the general course of the Gulf Stream is owing to the line of soundings on the coast, it must be regarded as a consequence, and not a cause, of the form of the bank against which it presses. It is well known, however, that farther north there is a counter current inside of the stream running in the opposite direction, and its superficial character shows that, here at least, its movement is independent of the form of the bottom. The direction of its current is in fact that of an eddy on a gigantic scale, and is caused, not so much by the form of the bottom at its origin, as by the constantly increasing resistance of water of a lower temperature; and perhaps it is in part to this resistance that we are to look for the origin of the inside counter currents at the north, which resemble those created by the land in retarding the tidal currents. The waters of the Gulf Stream are, moreover, too clear to admit the supposition, that they take any part in alluvial formations other than that already stated.

The question may also arise, whether the whole alluvial and subaqueous formations of this eastern coast of North America may not have been at one period united, and whether the channels that now separate them may not have been subsequently made by the draining of the continent, or some convulsive action of the sea. But the consideration of this view will be deferred until it is formally presented.

Section IV. — *Conclusion.*

Hitherto the *tides* have been regarded chiefly as an astronomical problem; but if the views brought forward in the preceding sections of this memoir are correct, they must hereafter be treated also as a strict geological problem, applicable to all ages of the earth's history.

It has been shown in the preceding pages that there are territories, more or less inhabited, which have been formed in historical times by the gradual accumulation of matter held in suspension, and carried by the waters of the sea; that this matter has been deposited chiefly in conformity with the laws of the tides; and therefore that the tides must have remained the same during the whole period of the deposit, their present courses and other conditions being due, in general, to the forms of the shores at the commencement of the actual epoch.

But the causes of the tides, and therefore the tides themselves, have always existed. We may ascend to an ancient geological period, when the regular progress of the tidal undulations was much less interrupted than now; still we must admit the existence of tidal currents so long as we conceive the interposition of shoals, islands, or continents in the path of those undulations. Theoretically speaking, then, we should expect to find a certain conformity between the oceanic deposits of all ages and the currents of the epochs in which they were made, which conformity should be the more apparent the nearer we come to the actual epoch. It has been pointed out that there exists a fixed relation on the part of the tidal currents to the *alluvial* deposits, in their structure, position, and amount; or, as the tidal currents depend on the form of the land, it may be said that on the south coast of New England this relation is maintained between the present deposits and the shores of the post-pliocene period. So distinct is this relation, that the character of the alluvial deposit on the borders and in the depths of the sea is readily determined when the direction and other circumstances of the local currents are known. This suggests a principle of conformation by means of which the geologists will be able to reason back from the forms of the earlier deposits to the currents of their respective periods.

It is the prevalent opinion among geologists that the most important and durable changes in the surface of the globe have been ushered in by epochs of convulsive disturbance. This is not the place to discuss the limits of these changes. It may be presumed that during these convulsions the operation of the tidal laws was overruled, or controlled. But since these laws are active and unchangeable, they must have struggled to regain their natural ascendency, to which they will have been restored in periods of quiet action. Accordingly the currents created by the tides are to be counted among the most effective of the natural agents at work throughout all periods of quiet action in giving their present form to the great continents; and thus the whole economy of the earth's condition appears to be as intimately connected with the regular movements of the ocean, depending upon astronomical influences, as with its occasional and tumultuous disturbances. This action of the tides, or, in other words, the influence in this manner of the moon upon the earth's surface, is a new application of the law of gravitation, which has been employed by the Author of the universe, not only in holding together the bodies of the system, but also in distributing the materials of which they are composed according to His plan of creation.

The *tidal theory* now introduced into geology does not assume the discovery of a new law, but indicates a new mode of operation of an established law. It conforms to that view to which all improvements in science seem to tend, — a simplification of the laws of creation.

Without designing to undertake any thing like a minute description of geological districts, I will proceed in a very brief and general manner to cite a few instances of the geological action of the tides in the past ages of the earth's history. The instances will be taken from the tertiary and subsequent periods, principally for the obvious reason that they have undergone fewer changes since the time of their deposition. The idea immediately suggests itself, that, if this theory of aqueous deposit be correct, we ought to find the alluvial, quaternary, and tertiary formations in close proximity to each other, particularly where those of an earlier period are so situated as to preclude the possibility of any great alteration in the transmission of the tide-waves during that long interval. Taking the first example from this country, it will be seen by a reference o Sir Charles Lyell's geological map of the United States, that the cretaceous, tertiary, and post-pliocene deposits lie along the borders of the coast, succeeding each other outwards in the order in which they are named. They appear to follow one another in regular course, according to the laws of tidal deposit, each period showing larger than that which precedes it, and which it overlies.

The post-pliocene, being outside of all, and accumulated on the shores of the Northern and Eastern States by the constant transporting power of the current of the flood, effected a gradual change in the progress of the tide-wave, diverting it more to the eastward. Long Island, and the islands on the southern coast of Massachusetts, all of which were the shoal formations of that period, contributed greatly towards this change. The locality of these islands was determined by the nucleus of a former period, and their form or outline must be ascribed to the action of tidal currents. In the case of Long Island,* the shoal commenced probably at the heights of Brooklyn, the highest part of the island, and was gradually built up towards the east. The deposit was at first assisted by the confluence of the tidal with the river currents; and afterwards by that of the tides of the Sound conflicting with those of the open sea, the former running at that time, as now, through the deep and rocky chasm of Hell-Gate.

The islands on the Massachusetts coast and the district of Cape Cod were constructed by a similar process, their forms also being due to the different directions and modes of action of the currents in that region. But as the eastern coast is the most exposed to the destructive action of the prevailing storms, its shores, being gradually acted upon and degraded as the continent was upheaved, now appear as precipitous cliffs, where the stratified deposits show to the greatest advantage.

* In the minute and able account of the geology of this island, particularly of the alluvial formations and their changes, by Professor Mather, the reader will find several cases in which this theory of the geological action of the tidal currents is applicable.

Below the stratified drift there may be seen at two points, Sankaty Head (Nantucket) and Truro (Cape Cod), a stratum of clay, which Mr. Desor and Mr. Edward C. Cabot regard as the eastern outcrop of a wide tertiary basin, extending below the islands of Nantucket and Martha's Vineyard, and forming the nuclei for the overlaying drift-beds when they were deposited in the condition of shoals.

There is some reason for assuming a similar superposition of strata of different ages in the great banks to the northeast of the continent. It is certainly not a matter of chance that there is no tertiary and so little stratified drift to be found north of Cape Cod. In order to account for their absence, we must admit that there has been formerly a far greater amount of dry land than now, which is not in accordance with the general features of the country; or we must conclude that in those periods the tidal current was, as it is now, too rapid to allow the formation of shoals along the coasts of Maine, &c., and that the materials held in suspension were consequently carried still further, and dropped in those great seats of deposit, George's, Newfoundland, and other banks in that vicinity. This assumption helps to explain both the extent of these banks and their height above the bottom of the ocean, which cannot without apparent difficulty be ascribed merely to the tidal deposit of the actual period. But as the quaternary deposits, being the last in order, have been accumulated on the northeast, so the alluvium, carried beyond them by the new course given to the tide-wave, is seen in the greatest quantities in the vast subaqueous deposits of the Nantucket shoals and banks, the great and little banks of George and Newfoundland, and those off the coast of Nova Scotia, before enumerated.

Passing from the coast to the interior, this theory of tidal action serves to explain the geological peculiarities of those great plains both of North and South America, the prairies and the pampas, which may be considered the deposits of gigantic bays during the state of subsidence of the continent.

On the continent of Europe and the British Islands, the primary rocks of Portugal and Spain, and the primary and secondary formations of the French and British coasts, have a general similarity of outline to the present shores. *Within these limits*, therefore, the transmission of the tide-waves has remained very nearly the same. Upon examining the geological map, a break is found to occur in these early formations, reaching from the western vale of the Lower Pyrenees to the entrance of the Gironde. This, which is the alluvial coast of the Bay of Biscay, noticed in the preceding section, is the external boundary of a vast basin of tertiary and drift deposits, the former being inside. Making a curve from Limoux towards Montpellier, the middle tertiary extends in a narrow belt between the chalk on one side and the transition series on the other, until it meets

the alluvial deposits of the Gulf of Lyons. Thus the matter deposited by the currents of the tides, acting in conformity with the principles here laid down, has become by subsequent upheaval the means of uniting the former island, but now peninsula, of Spain to the continent of Europe. This is an instance of bay deposit.

Another instance of bay deposit is the great tertiary basin of Paris, confined on the lower sides and to the west by the jurassic and cretaceous regions, and separated in part from the tertiary of Belgium by the upper chalk.

A third striking case of the bay deposit in the tertiary period is the clay basin of London, the limits of which are determined by the upper secondary, bounding it on all sides except at the entrance. The tertiary of Hampshire is a case of sound deposit, and that of Norfolk and Suffolk occurs (as has been said of the alluvium lying outside of it) precisely at the region of meeting of the tides coming from the Straits of Dover and the North Sea, where a convergence and retardation of the tide-waves creates the circumstances under which the sea parts easily with the matter held in suspension.

All the previous cases have been cited merely as examples. Having before me the magnificent geological maps of France, and the maps of other parts of Europe, it would be very easy to multiply the number of them; but these are sufficient for illustration.

An interesting application of this theory is suggested by Mr. Desor, as follows. Geologists have observed that there occur in the same geological horizon deposits differing entirely in mineralogical character and in fossil remains. Gressly, who with careful accuracy traced out the line of demarcation between such deposits in his *Observations sur le Jura Soleurois*,* and fully recognized their peculiarities, gave them a distinct classification, in which he included the muddy region (*facies vaseux*) and the shoal region (*facies de charriage*). If, adds Mr. Desor, the upheaval of this continent should affect the south coast of Massachusetts so as to expose the bottom of Cape Cod Bay or of Nantucket Sound, there would be seen in those places precisely the same varieties of formation and condition as in the tertiary of the Swiss valley. These geological peculiarities, then, are accounted for when we consider the latter as the sound and bay deposits of the tertiary period, and, this view being correct, it will be a future demand upon the attention of the geologist to endeavour to identify in similar cases all those varieties of form and conditions of deposit which are typified in the alluvial and subaqueous deposits of the actual epoch.

Professor A. Gray has called my attention to the manner in which this theory may be made to throw light upon the geographical distribution of certain plants. The dune

* Memoirs of the Helvetic Society of Science.

or alluvial flora of North Carolina is repeated, as he informs me, on the shores of New Jersey, of Long Island, and the southern and eastern coast of New England. Following the course of the tide-wave, these Southern plants are found at Plymouth (opposite Cape Cod), where there is a large bay deposit, and to the north of Cape Ann, in the bight formed by the projection of this cape, where also occurs another instance of bay deposit, at Ipswich, and Newburyport. Lastly, a few of these plants are found on the south coast of Nova Scotia. How far this reasoning may be thought to explain the existence of the same flora in the adjacent countries, situated on opposite sides of the same channel, and washed by tidal streams which, acting upon a system of rotation, have carried the same materials in succession to the shores of each, through the long ages of the past, is hereafter to be considered. A similar result will also be produced in two countries far remote from each other by the transmission of a tidal undulation which, leaving a bold and projecting coast, arrives, without intermediate interruption, at some distant point or island.

Having already dwelt longer than was intended upon this part of the subject, I will only make a hasty reference to the utility of this theory of the geological action of the tides in accounting for the great sand deserts, as it has been applied (in Sect. III.) to explain the Peruvian sand desert of Pachira.

The interposition of a continent (or chain of islands) occupying a great extent of latitude in the path of the elementary tide-waves, as is the case with Africa, may be supposed to offer the most favorable conditions for immense sand deposits exceeding all others in amount. Here the tidal currents would be employed, not only in distributing and collecting the detritus of the African mountains, but also in transporting a part of that of the Eastern continent and islands. The extent of the sand deserts, so characteristic of this part of the globe, is to be attributed mainly to the wide spaces between the higher grounds, or earlier formations, in which the various forms of deposit have been often repeated on a grand scale. These, however, and other geological details, are designedly left, on account of their number and diversity, to a future and not distant occasion.

But there is no point of view from which the geological action of the tides appears more interesting than in its connection with the geographical distribution of marine animals. It is well known to the zoölogist that the sea is the principal seat of animal life, and that it is near the land, and not in the distant depths of the ocean, that this life is displayed in the greatest amount and variety. It will be found upon inquiry that marine animal life is most abundant and most useful to man on the shoal formations. In this region are the great fishing stations, and, as fishes are predatory in their habits,

here also exist the smaller tribes that supply their food. It is only necessary to refer to George's and Newfoundland, Cashe's and Jeffries Banks, &c. Nearer the coast the smaller banks are resorted to habitually by fishermen, as the places most favorable to their pursuits. In all these shoal formations, however, there is a principle of distribution depending upon the relative depths of the water.

It has been ascertained by Mr. Agassiz, in his researches on the southern coast of Massachusetts and among the Nantucket South Shoals, that a depth varying from seven to twenty fathoms is, in this part of the open sea, most suitable to the existence of those classes of animals that either adhere to the materials of the bottom, like polypes, or that move always on the ground, not having the power to swim, as the radiata and worms. On the ridges or highest parts of the actual shoals no animals are found. They are marine deserts, in which no life, either animal or vegetable, can be supported.

In passing from the summit of one shoal through the intervening channel to the summit of another, the following facts have been repeatedly observed by Mr. Desor and myself.* The top of the shoal, which consists of fine sand, has always been found wholly destitute of the traces even of life. Upon descending a little, the dredge brings up from the side of the shoal, and near its base, large quantities of broken shells, which appear to cover the bottom in some places to a considerable depth. These shells are clean and water-worn, and have no polypes or animal remains attached to them. Still lower down, the freight of the dredge will consist of pebbly stones, rounded and smooth, and a few animals. The pebbles may have polypes (membranipora) on all parts of them, showing that they are liable to be moved by the agitations of the sea. From the lowest part of the channel or valley the dredge brings up stones of a larger size and more irregular shape, having rough and uneven surfaces, and covered on one side chiefly with polypes and barnacles, and, together with these stones, a great number of animals, such as echini, starfishes, worms, crabs, and numerous bivalves and univalves. The same succession will be repeated in the reverse order, on passing to the summit of the next shoal.

These facts may be thus explained. The shoals themselves are composed of materials not adapted for the support of life; and they rise so near the surface as to be subjected to the constant destructive action of the waves, which break upon them in all but the calmest weathers. Although their average height remains the same, yet the loose materials of which they are constructed are easily transposed, and must be occasionally increased and lessened by the alternate deposits of the tidal currents, and the destructive agitations of the sea in heavy storms. The shoals are, in short, in

* These facts were presented by Mr. Desor to the Scientific Convention recently held at Philadelphia.

a constant state of motion. The channels, on the other hand, are sheltered by the shoals, as well as defended from disturbance by their greater depth. This double protection secures a condition of permanent rest, requisite for the full development of marine animal life. The pebbles, higher up, notwithstanding that they are liable to be moved, appear to be sufficiently stable to become the base on which the ruder animals build, and the home for a few of the moving species. The dead and broken shells are to be included among those materials that are easily transported by the currents, for the collection of which the shoals serve as nuclei. In harbours and inclosed waters generally, animal life will exist in abundance at a less depth, because these positions are more protected by the land from the effects of the waves.

It is only with regard to the Nantucket Shoals that the depth varying from seven to twenty fathoms (from 42 to 120 feet) is specified as the most prolific. There is no intention of saying that these depths are universally the most abundant. Animal life is no doubt to be found elsewhere in similar quantities and diversities much farther below the surface. The greatest of these depths, however, is shallow compared with the abysses of the ocean, which must be wholly destitute of those classes that derive their sustenance from the bottom. By the help of the foregoing facts, we are able to account for the enormous display of marine fossils found in the earlier strata, and distributed throughout regions of great extent. The shallowness of the sea in those periods and at those places afforded the condition best suited to the fruitful development of animal life. And the changes that have led to the present inequalities of the bottom of the sea appear to have confined in a measure to the shoal formations of the actual period the homes and the support of that marine animal life which was formerly more widely diffused.

This, then, appears to be one of the grand results of the operation of the tidal laws, as disclosed in this paper. Throughout all periods of geology it has prepared the place suitable to marine animal life.

Another office performed by the tidal and normal currents of the sea has been to transport and diffuse, in great quantities, the loose materials of the ocean, and to increase the area of dry land by taking off and collecting together in plains the detritus of higher regions, filling up, in this manner, the empty spaces between steep and rugged boundaries, and giving form and body to the continents. Upon looking back to the early ages of geology, we can assign no date to the commencement of such operations other than that of the origin of the tidal currents; and these are coeval with the first appearance of land above the surface of the ocean. But as all these grand operations, by means of which the physical condition of the globe has been made to pass through its successive changes, are intimately connected with each other, and purposely ordered, and as the prevailing tendency of the present laws of tidal and oceanic current action

has been to increase the extent of land in the northern hemisphere, so an inquiry is naturally suggested into the relation between this theory of the geological action of the tides and that branch of physical geography which treats the progress of human civilization and development as dependent upon the material form and structure of those parts of the earth which have been successively inhabited by man.

And, finally, when we consider that it is those deposits which have been subjected to the influence and have followed the laws of tidal and current action that constitute man's most convenient dwelling-place, that are best fitted to provide the means of his support, and to facilitate intercommunication between the remote families of his race, we are led to regard these regular and systematic movements of the ocean as the agencies by which the earth was prepared for his reception, and as designed by Providence from the beginning to be the instruments of those changes in the face of the globe which were to precede the introduction of the human race, the great end of its creation.

Note. — In the second section of this memoir, a particular description is given of the manner in which indentations along the coast are converted into ponds by the gradual formation of alluvial belts across their openings, the sand being deposited by the flood current. It is quite common to find in the drift of Cape Cod several of these ponds lying along the same valley, or depression, one within the other, and separated by bands, more or less broad, of sand and gravel finer than that of the hills. It may be supposed that, when the communication between the innermost pond and the sea was open, the current, eddying round a projecting point, continued at every successive tide to leave its burden, until finally an inclosure was formed by the junction of the belt to the opposite side of the bay. And so with the other ponds in succession. It has been already remarked that these ponds *are often deeper than the adjacent sea*, and without doubt the tendency will be to disunion at the shallowest parts. Profiting by what has been made known concerning the Aralo-Caspian basin by Sir Roderick I. Murchison, in his *Geology of Russia in Europe and the Ural Mountains*, an analogy of condition may perhaps be traced between the inland seas and lakes of Southern Russia and the East, and the diminutive ponds of New England. This is truly *parvis componere magna*, but nevertheless the sentiment concerning time, which Sir Roderick has adopted as his motto, belongs equally to its correlative space: — *Le temps qui nous manque, ne manque point à la nature.*

"Judging," he says, "from the organic remains collected from numerous parts of the whole area, there can be no sort of doubt that all the masses of water now separated from each other, from the Aral to the Black Sea inclusive, were formerly united to this vast pre-historical Mediterranean." The Caspian evidently was connected with the Black Sea through the Caucasian belt of sand, gravel, and shells, and the Aral and Caspian interminged their waters through the low, sandy desert of Khivah.

"The low level of the adjacent eastern districts would lead us to infer that it [this sea] spread over wide tracts in Asia now inhabited by Turkomans and Kirghis," but it is not certain whether the lakes in this direction are also included in the same geological formation. It is interesting to know that the transition from purely oceanic to brackish water deposits is indicated on the west (only) by a partial intermixture of shells of each type (pp. 297 et seq.) The subsequent diminution of this vast body of water to such a capacity as rendered possible the divisional deposits is a fruitful subject of speculation to the geologist, and is discussed by Sir Roderick Murchison.

THE SOUTH EAST COAST of MASS.

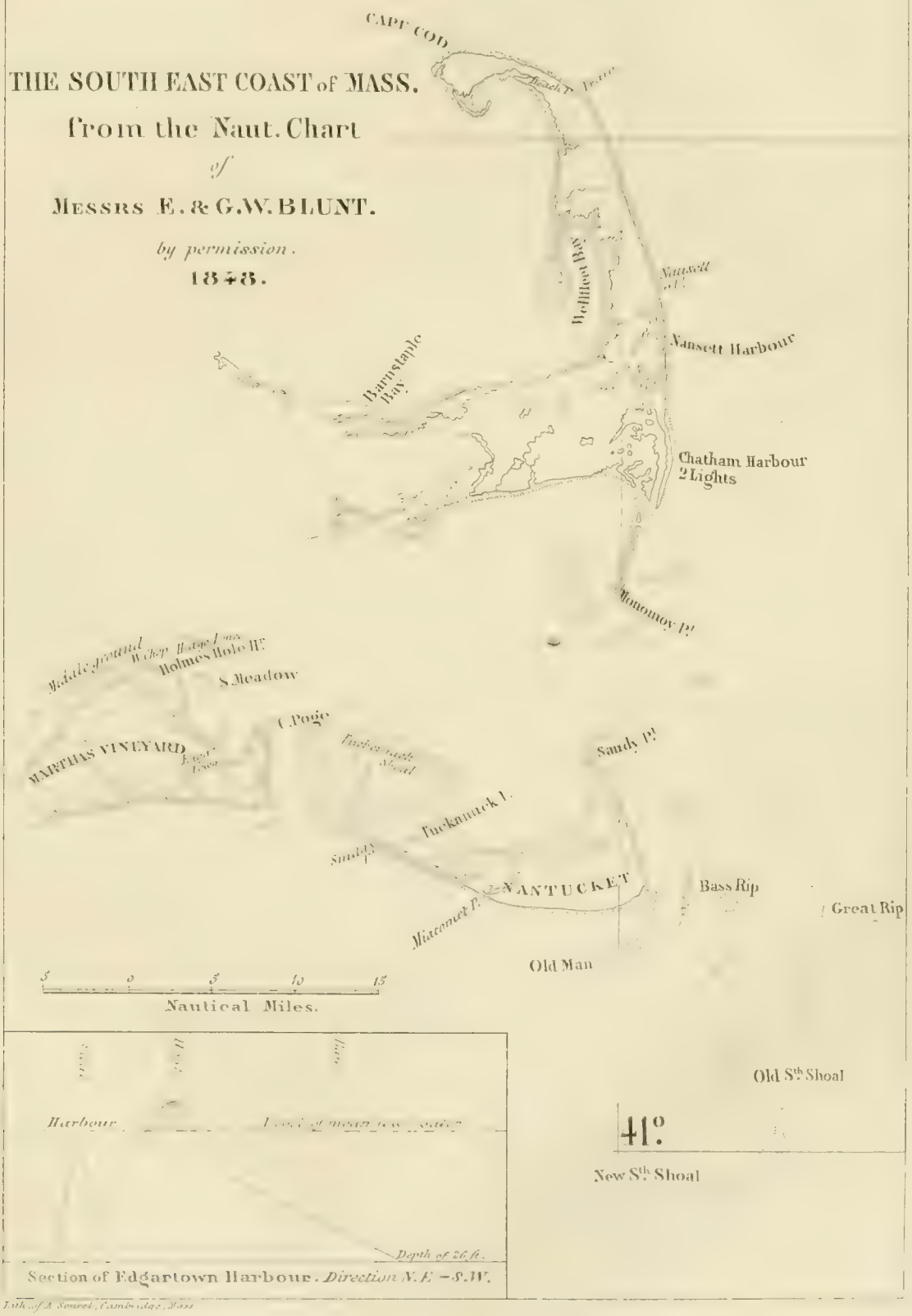
from the Naut. Chart

of

MESSRS E. & G.W. BLUNT.

by permission.

1848.



Lith. of A. Sowerd, Cambridge, Mass.

Pl. 2.

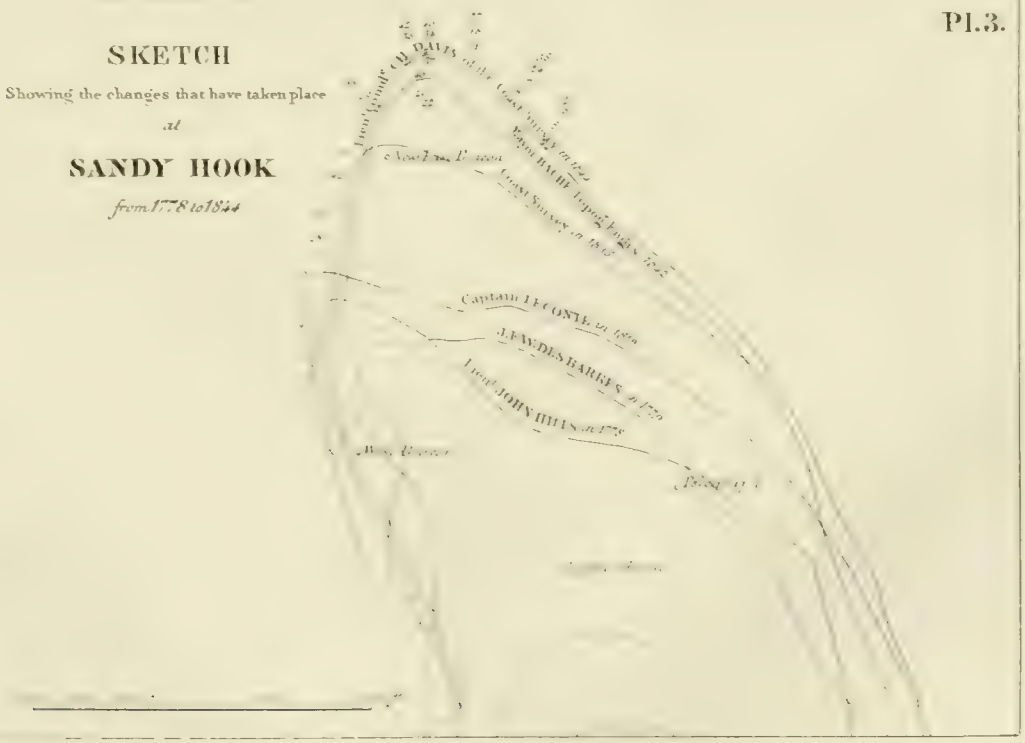
CAPE CODD

Taken from a Chart
of the N.E. Coast
composed
for Lord HOWE in 1764,
by
J.F.W. DES BARRES

Pl. 3.

SKETCH

Showing the changes that have taken place
at
SANDY HOOK
from 1778 to 1844



III.

History and Transformations of Corydalus cornutus.

By S. S. HALDEMAN, A. M.

(*With a Plate.*)

(*Communicated to the Academy, November 8th*, 1848.)

The study of the Neuroptera has of late years received a new impulse from the works of Pictet, Charpentier, De Selys-Longchamps, Siebold, and others. This order of insects is well represented in North America, which furnishes a considerable number of species still unstudied, besides several forms whose history is essential to a proper understanding of the order; so that, if the naturalist whose location is beyond the bounds of Europe is surrounded with difficulties arising from the want of access to extensive libraries and national collections, he has counterbalancing advantages in being able to add to the knowledge of species already known, or of pursuing his investigations in an independent direction.

The transformations of Corydalus cornutus, *Linn.* seem not to have been hitherto made known; although, from its size and the singularity of its appearance, it has for a long time attracted attention. In Pennsylvania it appears in the perfect state in July, or a little earlier, and scarcely reaches the month of August before it disappears for the season. It is not abundant, and although the larvæ and pupæ are sufficiently common, many perish before the final transformation. I have seen as many as ten perfect individuals in a season, of which the males exceed the females at least tenfold. An entomological friend informs me that during three years he has seen about twenty, of which but one was a female. Although well known to most people in the localities where it is found, I have never been able to discover that it has a vernacular name, either in English or German. As regards vulgar names in books, appearances seem to indicate that the vernacular crudities which deface the pages of so many European works will not be likely to make their appearance very soon upon the western side of the Atlantic.

This insect may be seen upon a wall about sunset, resting perfectly still, the head in a line with the body, which rests flat, probably waiting for the darkness of night to take flight, as it does not usually take wing during the day. It is easily captured, being very sluggish in all its movements, walking and flying heavily; and if dislodged from an elevated position, it falls to the ground with outspread wings, without making an effort to escape by flight. When disturbed, a threatening aspect is assumed; the shining hemispherical eyes are conspicuous, the head and thorax are elevated, and the mandibles are opened and closed upon objects with sufficient force to puncture the skin, although incapable of inflicting any serious injury. The repugnance to the general appearance is heightened in the endeavour to capture the insect, which would naturally be attempted by a seizure upon the back; but the jaws are ready at every point, and by means of the well-developed *elevatores capitis et prothoracis* muscles, the head and thorax are turned so far over the back as to form a circle with the upturned abdomen. If the capture be persisted in, the wings expand, and a white fetid liquid excrement is ejected; the quality of which indicates the use of animal food, although I am not aware that food is taken in the perfect state. These observations apply to both sexes.

1. Larva. (Pl. I. Fig. 1.)

The larva is oblong, depressed, tapering towards the posterior extremity; dark-brown, marked on the head and thorax with flavous impressed punctures and confluent depressions; head above and below, with the entire thorax above, of a corneous texture. Abdomen soft, the integument thick and tough, eight segments with lateral (imperforate?) spiracles and branchiæ, each of the latter composed of several filaments; ninth segment without branchiæ, except upon the divided caudal appendage, each division of which has a simple filament, and a pair of curved hooks. The prothoracic spiracle is situated in the connecting skin between the prothorax and mesothorax. The inferior surface of the ninth abdominal segment has a velvet-like pad, a smaller one being also attached to each division of the caudal appendage. The seven anterior abdominal segments have each, near the insertion of the lateral branchiæ (fig. *b*), an inferior brush or bundle of short fibres (*b'*) which seem to be accessory branchiæ. The setæ upon the lateral branchiæ are slender, whilst those upon the accessory branchiæ are short, thickly set, and somewhat flattened.

The head is transversely subquadrate and depressed; the clypeus and labrum (fig. 2) prominent; eyes (fig. 1, *a*) lateral, not prominent, simple, each composed of six lenses. Immediately anterior to these are the antennæ, which are small, composed of four cylindrical articulations, the basal one of which is solidly attached to a small oval scapus (*s*)

which moves freely in the torulus (*t*). The mandibles (fig. 2, *m*) are robust, with the apex strongly 4-dentate. Maxillæ (fig. 3, *m'*) composed of a short cardo, and a straight stipes flattened above and convex below, the sides parallel and the inner margin ciliated, the apex rounded, with two articulate projections representing the labial palpi and maxillary lobe. The former is composed of three, and the latter of two articulations. The labium (*l'*) is corneous, transverse, with the margin undulate, and it has small 3-articulate palpi. Figure 2 represents the superior, and figure 3 the inferior part of the head enlarged, with the form of the various parts as they are exposed by the separation of the sutures, when the external parts are cast off to enter the pupa state. In figure 2 the labrum, clypeus, post-clypeus, mandible, and antennæ are apparent; the post-clypeus separated from the epicranium, from which a small piece is detached by a suture posteriorly. Figure 3 exhibits the corresponding inferior parts, with the separation of the epicranium.

Habits. — The larva is predaceous and aquatic, walking upon the bottom, and not very active. Its locomotion is forwards, but when it is disturbed, it draws itself rapidly backwards by means of the caudal hooks, which are attached to the surface, and the body drawn up. When disturbed, it exhibits the propensity of the imago to bite. The head is sometimes cleaned by passing the anterior feet over it. It is found in the spring of the year from a short distance to fifty feet or more from the water, where it takes refuge beneath a stone or log, forming an oval cavity in the earth, where it remains some time (probably not less than two weeks) awaiting its change. It will live in confinement four or five days without being wet, so that it is probable that the spiracles are used for aerial respiration.

Sexes. — In the male larva (and also in the pupa) the head and mandibles are a little larger than in the female, although the form is identical; and it has a small tubercle upon the middle of the prosternum near the insertion of the feet, somewhat resembling that in the orthopterous genus Acrydium. Figure 1 represents a male larva when full grown.

2. Pupa. (Pl. I. Fig. 4, 5.)

The body of the pupa is curved in a semicircle, and it becomes narrower and more nearly cylindrical, the chief difference (when compared with the larva) being apparent in the prothorax and abdomen. The head resembles more nearly that of the adult, except the mandibles, which are toothed in both sexes, and do not differ essentially from those of the larva. An elevated ridge extends backwards from the posterior portion of the eyes (fig. 5). The wings are deflexed, and, with the feet, rest loosely upon the breast.

The antennæ are about three fourths of an inch long, curving over the posterior angles and beneath the head, and the articulations are much contracted. Labium (fig. 6, representing the head beneath) fleshy and bifid, each side obtusely rounded; labial palpi 3-articulate, last articulation fusiform and acute. Maxillæ with two fleshy lengthened triangular lobes, the inner one smallest, the external one with a small spine at the apex; maxillary palpi with five short articulations. Most of the external parts are covered with scattered hairs.

To allow the imago to escape, the integument of the pupa splits transversely behind the antennæ, and longitudinally from this line to the metanotum, into which the cleft is continued for a very short distance.

Habits. — The insect does not remain long in the pupa state, in which it is inactive, although capable of moving the body in a small degree. Near the period of its final change, however, it acquires the power of walking, although in a very feeble manner; and it seems probable that this power is seldom used.

3. Imago. (Pl. I. Fig. 7.)

The general color is gray; the head and thorax brownish, these variegated with spots of pale-flavous. The head and prothorax are minutely scabrous, except the portions spotted with flavous, a character which approximates the imago to the larva. The color of the recent insect scarcely differs from that of cabinet specimens.

Prothoracic spiracle (fig. *e*) resembling, like the others, a bivalve shell, but it has the addition of a fleshy pad covered with long hairs, placed at its lower point. Eyes hemispherical, three fourths of a line in diameter; size of the facets .01 of a line, or not more than half the size of those in Libellula and Aeshna. The heart makes from 36 to 40 pulsations in a minute. The feet are weak and slender, and the tarsi (*t*) pentamerous.

The most important peculiarity in the structure of the perfect insect is a complete perforation through the head at the anterior base of each antenna, mentioned by me in the *Proceedings of the Academy of Natural Sciences of Philadelphia*, Vol. II. p. 192. They are present in both sexes, and are sufficiently large at the narrowest part to admit a bristle, and from this point they enlarge upwards and downwards. They are situated at the internal extremity of a transverse impression above, and in the angle of a curved fissure beneath, which separates the post-mentum from the cranium. They are represented by the semicircular lines shown between the eyes, in figure 8. There is no interruption in the solid exterior of the head as it passes through and lines this perforation, so that thus far it has afforded no additional information as to the functions of the antennæ.

The three ocelli are arranged in a triangle, the anterior one being directed forwards, and the others diagonally outwards and backwards. There is a small spine behind the eye, and another larger one at the posterior angles of the head. Except the mandibles, the oral organs are soft and membranaceous. They are represented by figure 8, and the labrum at *l*.

Sexes. — In the male (fig. 7) the antennæ have about 60, and in the female 54 articulations, so that they are a little longer in the former sex, which has the apex of the abdomen provided with two pair of forceps. The mandibles in the male are large, somewhat depressed at base, tapering and arcuate, resembling horns; they are three times the length of the head, and somewhat irregular in form and direction. They are round except at the apex, which is pointed, and notched so as to present a sharp, cutting edge, less than a line in length. This peculiarity is not represented by M. Blanchard in the new edition of the *Règne Animal*, pl. 104, fig. 1. That author figures the head of the female on the same plate, fig. 2, and it is represented in Dr. Leidy's dissections of the imago. Figure *a* represents the base, and *a'* the middle portion of an antenna in the male, and *a''* the apex in the female.

The form and armature of the mandibles in the female resemble those of the earlier stages. It is a remarkable circumstance, that sexual peculiarities as distinct as those presented in the mandibles of this genus should not be conspicuous in the early stages; and the fact that these organs are essentially the same in the larva, pupa, and female imago, affords an additional proof to the opinion that the female is an undeveloped condition of the male sex.

The earlier form of the orthography of the name, *Corydalus*, is preferable to that of *Corydalis*, which is homonymous with that of a genus of plants.

IV.

Internal Anatomy of Corydalus cornutus *in its three Stages of Existence.*

By JOSEPH LEIDY, M. D.

(*With Two Plates.*)

(*Communicated to the Academy, November 8th*, 1848.)

I. Of the Digestive Apparatus.

1. *In the Larva.* — The insect, being predaceous in habit, has a structure of the digestive apparatus in accordance with the nature of its food.

The alimentary canal is a little longer than the animal, in consequence of a single short convolution of the small intestine.

The mouth opens in an infundibuliform manner into a wide œsophagus, which latter extends backwards through the pro- and meso-thorax, gradually dilates, and forms between the meso- and meta-thorax the proventriculus.

The œsophagus is thick and strong, and presents distinctly to view three tunics: the external, a delicate, transparent, filamentous lamina; the central, a muscular lamina, composed principally of transverse fibres; and the internal, or mucous layer, which is thrown into six plicated, more or less regular longitudinal folds, extending its whole length.

The proventriculus is a strong gizzard, ovate in form, and gradually contracted at its posterior part, forming a tube narrower than the œsophagus which passes back into the abdominal cavity. It is only separated from the œsophagus by a change in structure. Its thickness generally is not greater than that of the œsophagus, but is strengthened by stout muscular columns, projecting in its length from the inner surface of the cavity. These columns are twelve in number, and are exceedingly regular in regard to position and form. Six of them are broad, and alternate with the other six, which are comparatively narrow. They may be considered as defining the cavity of the proventriculus. The broader columns are on a line with, and correspond to, the œsophageal folds. Each of them consists of two portions: an upper pyramidal, and a lower tile-like or flat por-

tion. The pyramidal portion of the broad columns has its base anterior; the apex is posterior, compressed laterally, and unattached to the surface of the cavity. Each of the free sides of this portion possesses an oblong space, covered by short and stiff hairs: the sides of the apex are also furnished with hairs, which are two or three times longer than the others. The flat portion of these columns is a muscular basis for the attachment of stomachal teeth. These teeth are composed of a hard, corneous substance, are broad and concave posteriorly, projecting in a pointed process at the anterior part of the concavity, and elongated forwards into a manubrium. The three alternate of these bodies are rather narrower than the others. The six intermediate columns are narrow and cochleariform, and only extend the length of the pyramidal portion of the broad columns. The columns, as well as the intermediate spaces, are covered by a moderately thick epithelium. The posterior tubular portion of the proventriculus presents a number of longitudinal folds internally, and opens into the ventriculus.

The ventriculus is a quadrilateral receptacle, apparently formed by the apposition of four cylinders which anteriorly diverge slightly, and form as many cœcal pouches lying along the posterior proventriculus. The walls of this cavity are thin, and the internal surface is smooth. It contained a fluid matter of a whitish, granular appearance.

At the commencement of the fifth abdominal segment the ventriculus opens into the large intestine. The latter is separated from the former by a contraction, at which point the biliary tubes open. Commencing somewhat dilated, the large intestine then contracts, and forms a short convolution forward, then gradually dilates, and proceeds towards the anus, before reaching which it becomes gradually contracted again. The large intestine is thin, corrugated, and dilatable. Salivary glands do not exist.

The biliary tubes are eight in number, long, convoluted, and closely applied to the sides of the large intestine. They open at the contraction separating the ventriculus from the large intestine.

2. *In the Pupa.* — The œsophagus is narrower than in the larva, is cylindrical, and pretty uniform, and extends backwards as far as the commencement of the metathorax, where it opens into what corresponds to the ventriculus of the larva. It does not present the internal folded appearance of the larva, and the apparatus of the proventriculus of the latter has entirely disappeared in this stage; but as a substitute, we find a crop within the metathorax opening into one side of the œsophagus. This crop resembles the sucking stomach of many Lepidoptera, is simple, and lies folded upon the œsophagus. It was usually found empty.

The ventriculus is capacious, and extends from the termination of the œsophagus nearly to the posterior part of the third abdominal segment. It is of an elongated ovate

form, the narrow end being posterior, and bulges a little more on one side than upon the other. Passing off from it anteriorly are four cœca, surrounding the œsophagus, and corresponding to those formed by the apparent division of the ventriculus in the larva; but they are double the length, and different in form. They are somewhat sacculated; the two dorsal ones are comparatively narrow and pointed; the other two have a rounded and dilated extremity. In structure the ventriculus of the pupa is stronger than that of the larva, its muscular tunic being better developed. The cœca are thinner than the ventriculus. Both of the latter were filled with a white, semifluid substance. The large intestine differs slightly from that of the larva, except that it is more abruptly dilated about its lower third. The biliary tubes have the same character and relations as in the larva.

3. *Imago.* — The œsophagus in the imago has become much elongated; commencing with the same diameter as in the pupa, it very gradually widens, and within the abdomen dilates into a spacious proventriculus, which extends as far back as the fifth abdominal segment. The form of the œsophagus and proventriculus resembles that of a long-necked Florence flask. From the posterior part of the proventriculus, on its dorsal aspect, there projects a short cœcum, which appears to be the remains of the crop of the pupa. In structure the œsophagus and proventriculus are thin, and were generally found much distended with air. The proventriculus joins the ventriculus by a short, narrow tube.

The ventriculus presents but little variation from that of the pupa; it is in a more contracted state, and consequently is fusiform in shape, and, from the lengthened œsophagus, is placed more posteriorly in the abdomen. The cœca lose the sacculated appearance, are all obtuse at the extremity, and are applied to the sides of the proventriculus.

The large intestine presents a larger convolution than in either of the other stages, is very rugous, the rugæ disappearing by inflation; and it abruptly dilates into an oval or fusiform cœcum in its lower third, which latter opens into the rectum.

The cœcum is moderately thick and strong, and has developed upon it a double row of glands. Each row, commencing at the posterior part of the cœcum on its dorsal aspect corresponding to each side of the rectum, proceeds forwards to the front of the cœcum and turns down to its ventral surface, and then continues backwards to a point corresponding to their commencement superiorly. The glands are oval in form, white, and placed at pretty uniform distances from each other, beneath the lining membrane of the cœcum and resting upon its muscular and outer tunic. In structure they are composed of a layer of simple organic nucleated cells. The cœcum contained the same substance which in the pupa was found in the ventriculus. The rectum comes off from the cœcum opposite the posterior part of the antepenultimate abdominal segment, and proceeds as a narrow canal to the anus. The biliary tubes are the same as in the other stages.

4. *Comparison of the Changes which take place in the three Stages.* — The comparatively wide œsophagus and proventriculus of the larva, which extend as far back as the third abdominal segment, we find contracted in the pupa and shortened to the posterior part of the mesothorax; the proventriculus with its apparatus of stomachal teeth has disappeared, and a small crop exists in its place, whilst in the imago we find the œsophagus again lengthened, still contracted at its commencement, but gradually dilating as it passes backwards, until it finally forms a capacious proventriculus, which, with the œsophagus, extends as far back as the fifth abdominal segment. The proventriculus of the imago has no return of the teeth of the larva, is thin in its walls, and has a small cœcum posteriorly, which is apparently the remains of the crop of the pupa. The columnar ventriculus of the larva, with its short anterior cœca, we find becoming converted into the elongated cœca of a newly developed fusiform ventriculus of the pupa; and in the imago we find the ventriculus contracted and the cœca somewhat changed in form. The large intestine shows but little change in passing from the larva to the pupa, but in the imago we find a cœcum, and numerous glands formed upon it. Within the posterior abdominal segment on the ventral aspect of the terminal portion of the large intestine, in all the stages, there exists an irregularly ovoidal sac, which contains a greenish viscid fluid. The exit of this sac, which is probably urinary, is at the edge of the anal orifice.

II. Generative Apparatus.

In the larva the organs of reproduction exist in a very rudimentary state. The ovaries and testes have the same appearance, being elongated-ellipsoidal in form, composed of transverse fibres or indistinct tubules joining a common tube, and containing round bodies or organic cellules undistinguishable in any of the individuals examined. They are situated one upon each side of the small intestine, and from their posterior part proceeds a tube which joins its fellow beneath the urinary sac.

In the pupa the apparatus has become much more developed. The testes of the male have become much increased in size, and elongated as far forwards as the metathorax. The tubuli seminiferi are short tubes transversely situated, and all converging to the vas deferens. They contain spermatozoa in various stages of development.

The ovary of the female has also increased in length, though not to such an extent as the testicle, but has gained upon the latter in breadth from the lengthening of the ovigerous tubules. The ovarian tubules contain numerous ova in an immature condition, and sufficiently transparent within the tubuli to render their vitellus visible. In the male imago the testes have reached their highest point of development. They do not differ much in appearance from those of the pupa, excepting that in the individual particularly examined they were rather shorter. The tubuli appear more engorged, and contain per-

fectly formed spermatozoa. The vasa deferentia converge and join beneath the urinary sac to form a short ductus ejaculatorius, which latter terminates by an orifice at the extremity of an insignificant papilla, the only trace of a penis, existing upon the ventral surface in the interspace between the penultimate and last abdominal segment.

Attached to the last abdominal segment are four articulated appendages, which appear to have for their purpose the retaining hold of the female in coitu. In the female the ovaries are large, about two thirds the length of the testicle of the male, but three times as broad, and thicker. Each ovary consists of numerous ovigerous tubes, transversely arranged, commencing in fine points and gradually dilating to their termination in the oviduct. The tubes are held together, as well as the ovary in its position, by the numerous ramified tracheæ. Each ovarian tube contains ova in various stages of development, from a mere point at their commencement to two lines in length at their termination. There are generally from four to five ova matured, or nearly so, in each tube.

The mature ovum is about two lines in length and elongated-oval in shape.

The oviduct at its commencement forms the base of the ovigerous tubes, the opposite wall to the openings of which is thin and transparent. It becomes contracted at the posterior part of the ovary into a tube, which, passing backwards a few lines, joins its fellow to form a common tube, about a line in length, terminating in the vagina.

The vagina lies beneath the urinary sac, within the penultimate abdominal segment. It is a short, rounded receptacle, ending in a perforated papilla, rather longer than that of the male, between the ventral plates of the last and penultimate abdominal segments. From the foregoing description of the genitalia it is seen there is no true intromittent organ in the male, and almost no receptacle for such an organ in the female. I think it probable that the papilla, terminating the generative organs in both sexes, are applied together in coitu, whilst the female is retained in position by the abdominal appendages or claspers of the male.

III. Nervous System.

The number of centres or ganglia, in correspondence with the number of free movable segments of the body, remains the same throughout the three stages of existence. The ganglia, as is usually the case in the Neuroptera, are well developed or large in size, and, in correspondence with the activity of the animal, give off numerous nerves.

1. *Particular Description in the Imago.* — The cerebrum, with its lateral productions, the optic nerves, forms a cylinder extending between the eyes and presenting four swellings. From its upper surface pass off three nerves to the simple eyes; anteriorly, the antennal nerves and the arched commissures to the frontal ganglion; and inferiorly, the cerebro-cerebellar commissures.

The cerebellum, or first ventral ganglion, is situated within the head, just posteriorly to the cerebrum, beneath the œsophagus. It is large, cordate in form, and gives off anterior branches to the mandibles, maxillæ, and antennæ, and posteriorly the prothoracic commissures to the prothoracic ganglion. The frontal ganglion is large and triangular. It gives off anteriorly two branches to the labrum, several minute branches laterally, and posteriorly a single trunk, which, passing beneath the cerebrum, is applied to the œsophagus, to which it sends off numerous minute branches, and is finally lost in it.

Two small respiratory ganglia also exist upon each side of the œsophagus, connected together by a short commissure and with the cerebrum by means of a similar commissure.

The ventral chain consists of eleven ganglia, excluding the first or cerebellum; three thoracic and eight abdominal.

The thoracic ganglia are considerably larger than those of the abdomen, are hexagonal in outline, and present an elliptical longitudinal swelling on each side of their middle line. The commissures connecting them are at first widely divergent, and then convergent so as to leave wide elliptical spaces between them. The first thoracic or the prothoracic ganglion is situated at the posterior part of the prothorax, and gives off laterally branches to the muscles which occupy the prothorax and a large branch to the first pair of legs. The second thoracic or the mesothoracic ganglion is situated just behind the centre of the mesothorax, and is the largest of the thoracic ganglia. It gives off laterally nerves to the first pair of wings, three branches to the muscles occupying the cavity of the mesothorax, and a large branch to the second pair of legs. The third thoracic or the metathoracic ganglion is situated very nearly in the centre of the metathorax, and is a very little smaller than the prothoracic ganglion. It gives off laterally a large nerve to the second pair of wings, three nerves to the muscles within the metathorax, and a large branch to the posterior pair of legs.

The abdominal ganglia are small trapezoidal knots, and, with the exception of the first and last, are placed at the commencement of their respective abdominal segments: the first being situated near the centre of the first abdominal segment, the last in the posterior part of the same segment which contains the one immediately preceding it. They are of nearly uniform size, and, with the exception of the last one, send off six nerves on each side to be distributed to the parts within the corresponding segment. The last ventral ganglion supplies the eighth and ninth abdominal segments.

In the larva, as in other Neuroptera, several simple eyes are substituted for the compound eye. In this insect they are six in number, and situated so as to look laterally and forward. The cornea is convex externally, and internally projects into the eye in the form of a cone with a rounded apex, which arrangement supplies the deficiency of a crystalline lens. The cone is not distinct from the cornea, and both are formed of thin

and transparent superimposed laminæ. The optic nerve, on reaching the base of the simple eyes, sends off as many cylinders, each of which passes outwardly to meet a corresponding projecting cornea. Each cylinder of the optic nerve and the inner projecting part of the cornea form a cylinder surrounded by the membrana choroidea, which latter passes a short distance between the nerve and cornea, forming a sort of iris.

Explanation of the Figures.

Plate II. — Principally exhibits the digestive apparatus of Corydalus cornutus.

Fig. 1. Represents the digestive apparatus of the larva, magnified two diameters: — *a.* œsophagus; *b.* proventriculus; *c.* ventriculus; *d.* large intestine; *e.* biliary vessels; *f.* urinary sac; *g.* testicle or ovary.

Fig. 2. The digestive apparatus of the pupa (male), magnified two diameters: — *a.* œsophagus; *b.* crop or proventriculus; *c.* ventriculus; *d.* cœca of ventriculus; *e.* large intestine; *f.* biliary vessels; *g.* urinary sac; *h.* testicle; *i.* vas deferens.

Fig. 3. The organs of digestion of the imago *in situ*, magnified two diameters: — *a.* œsophagus; *b.* proventriculus; *c.* cœca of the ventriculus; *d.* large intestine; *e.* cœcum of the large intestine, much distended and exhibiting its two rows of glands; *f.* rectum; *g.* urinary sac; *h.* main tracheal trunk, dividing into two large branches passing to the thorax and head; *i.* dorsal vessel.

Fig. 4. The lower portion of the alimentary canal of the imago, dissected out, magnified two diameters: — *a.* proventriculus; *b.* cœcum of proventriculus; *c.* ventriculus; *d.* cœca of the ventriculus; *e.* large intestine; *f.* cœcum; *g.* rectum; *h.* biliary vessels turned forwards; *i.* urinary sac.

Fig. 5. The same as fig. 4, from another individual, in which the parts were more contracted.

Fig. 6. The proventriculus of the larva laid open to its inner surface, magnified: — *a.* folds of the mucous membrane of the lower part of the œsophagus; *b.* muscular columns of the proventriculus; *c.* stomachal teeth.

Fig. 7. Front view of one of the muscular columns and teeth of the proventriculus, highly magnified.

Fig. 8. Side view of fig. 7.

Plate III. — Principally represents the nervous system and generative apparatus of Corydalus cornutus.

Fig. 1. The nervous system of the imago, magnified three diameters: — *a.* cerebrum; *b.* cerebellum; *c.* the three thoracic ganglia; *d.* abdominal ganglia.

Fig. 2. Two fragments of the eye of the larva, highly magnified, exhibiting the internal appearance of the conical projecting cornules.

Fig. 3. A longitudinal section of a cornule, highly magnified and exhibiting its laminated structure.

Fig. 4. An ideal section of one of the simple eyes of the larva, presenting the cornule projecting inwards, *a*; the optic nerve outwards, *b*; and the choroidea folding around the projecting portions, *c*.

Fig. 5. Testes of imago, magnified two diameters.

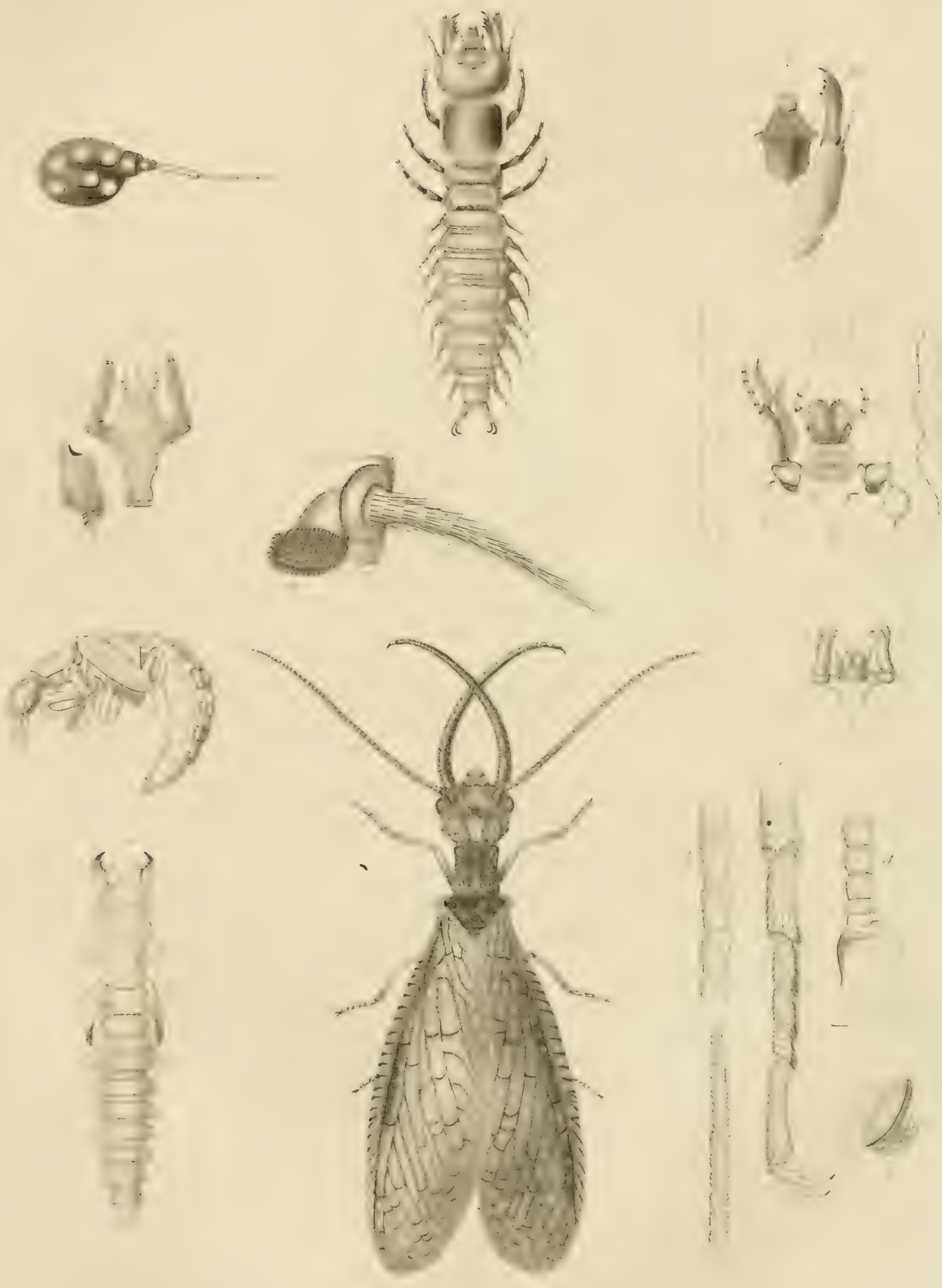
Fig. 6. Dorso-lateral view of the termination of the abdomen of the male imago, magnified two diameters, exhibiting the four prehensile hooks for attachment to the female.

Fig. 7. Ventral view of fig. 6: — *a.* generative aperture.

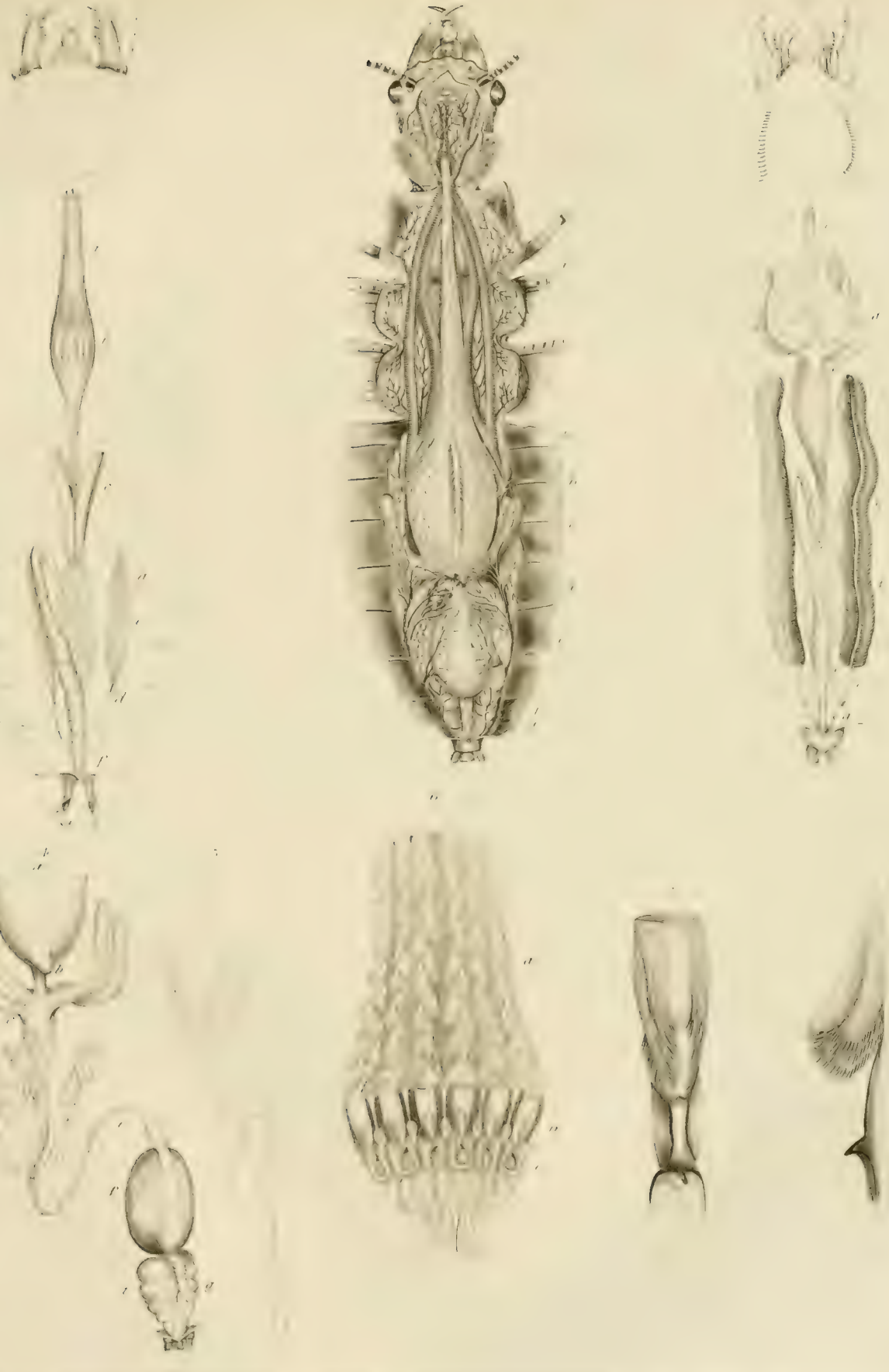
Fig. 8. Same view of the termination of the abdomen of the female: — *a.* generative aperture.

Fig. 9. Generative apparatus of the female, magnified two diameters: — *a.* ovary; *b.* oviduct; *c.* vagina.

Fig. 10. A single ovigerous tube, magnified six diameters.

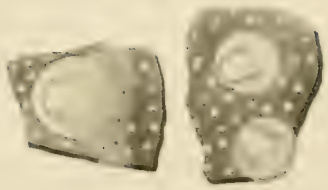


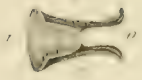
TRANSFORMATIONS OF CORYDALUS CORNUTUS

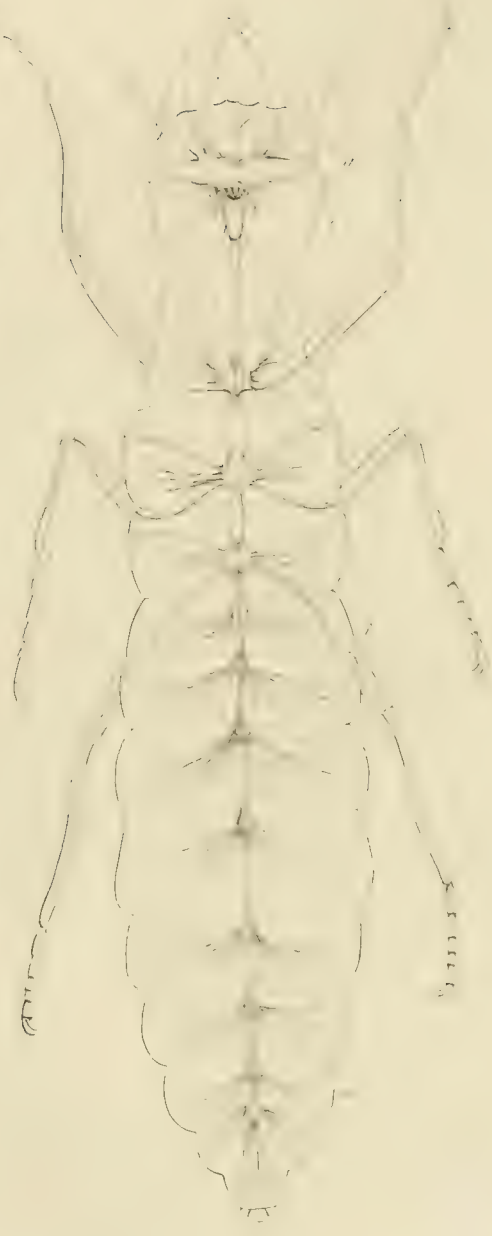


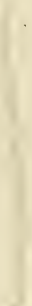
Joseph Leidy, del 1846

ANATOMY OF CORYDALUS CORNUTUS









Joseph Leidy, del. 1846

V.

Contributions to the Bryology and Hepaticology of North America.

By WILLIAM S. SULLIVANT.

PART II.

(*Communicated to the Academy, November 8th*, 1848.)

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1. Leskea Fendleri (sp. nov.): hermaphrodita; caule intricato-repente ramosissimo, ramis brevibus surrectis; foliis imbricatis erecto-patulis ovato-lanceolatis serratis evanidi-costatis; capsula oblonga suberecta subæquilaterali, operculo elongato-conico.

Hab. On rocks, in the vicinity of Santa Fé, *Mr. Fendler.**

* The following list of Mosses and Hepaticæ, collected in 1847 near Santa Fé, New Mexico, by Mr. Fendler, will be interesting to the bryologist as indicating the range of species. It is proper to state that Mr. Fendler's knowledge of these orders was very limited, and that their collection was with him a secondary object; also that the adjacent mountains furnished none of the species here enumerated, the valley of the Rio Chiquito, or Santa Fé Creek, being his principal locality. — Atrichum angustatum, *Beauv.* Barbula mucronifolia, *B. & S.* B. ruralis, *Hedw.* Bartramia fontana, *Brid.* Bryum argenteum, *L.* B. cæspiticium, *L.* B. crudum, *Schreb.* B. Duvalii, *Voit.* B. inclinatum, *B. & S.* B. intermedium, *Brid.* B. pseudo-triquetrum, *Schwægr.* B. pyriforme, *Hedw.* B. Wahlenbergii, *Schwægr.* Ceratodon purpureus, *Brid.* Dicranum Muhlenbeckii, *B. & S.* D. rhabdocarpum, *Sulliv.* Encalypta ciliata, *Hedw.* E. rhabdocarpa, *Schwægr.* Fabronia pusilla, *Schwægr.* Fissidens bryoides, *Hedw.* Fontinalis antipyretica, *L.* Funaria hygrometrica, *Hedw.* Grimmia calyptrata, *Hook.* G. ovata, *W. & M.* Hedwigia ciliata, *Hedw.* Hypnum atrovirens, *Schimp.* H. catenulatum, *Brid.* H. cupressiforme, *L.* H. diversifolium, *Schimp.* H. luridum, *Swartz.* H. riparium, *L.* H. ruscifolium, *Neck.* H. salebrosum, *Hoffm.* H. stellatum, *Schreb.* Leskea attenuata, *Schreb.* L. Fendleri, *Sulliv.* L. polyantha, *Hedw.* L. Sprucii, *Mont.* L. tenuirostris, *B. & S.* Mnium cuspidatum, *Hedw.* M. serratum, *Brid.* Neckera oligocarpa, *Schimp.* Orthotrichum anomalum, *Hedw.* O. cupulatum, *Hoffm.* O. speciosum, *N. ab E.* O. Sturmii, *H. & H.* Polytrichum juniperinum, *Hedw.* Pottia subsessilis, *B. & S.* Pterigynandrum nervosum, *Brid.* Schistidium ambiguum, *Sulliv.* S. pulvinatum, *Brid.*

Descr. Planta late denseque cæspitosa. Caules prostratæ intricato-implexæ, ramos breves erectos teretes 3–4 lineares simplices vel ramulosos emittentes. Folia undique imbricantia erecto-patentia ovata longe-acuminata, vel ovato-lanceolata concava, margine inferiore reflexa, fere toto ambitu serrata, costa paulo ultra medium evanescente instructa, tenuissime lineari-areolata, cellulis ad angulos basis externos amplis quadratisque, e lutescente viridia nitentia. Perichætialia convoluta-oblonga ex apice lato rotundo laciniato-dentato in productionem linearem serratam flexuosam subiter desinentia. Antheridia archegoniis immixta ad vaginulæ basim; paraphysibus numerosissimis. Capsula oblonga, nunc subæqualis erectiuscula, nunc altero latere longiore convexiore paulo inclinata, ore subobliquo. Peristomii exterioris dentes lineari-lanceolati dense trabeculati, linea mediali notati; interioris processus e membrana lata carinati lineares pertusi longitudine dentorum, ciliolis rudimentariis vel nullis interpositis. Annulus compositus revolubilis. Pedunculus e caule flexuoso-erectus 5–7-lineas longus, basi lenissime papillosus, superne sinistrorsum, inferne dextrorsum tortilis. Operculum convexo-conicum, plus minus elongatum, rectum vel incurviusculum. Calyptra non visa.

Tab. I. — *Fig.* 1. A plant of the natural size. 2. The same, magnified. 3. A portion of stem. 4. The peristome. 5. Capsules. 6. Opercula. 7. The annulus. 8. The perichæth. 9. Archegonium, antheridium and paraphysis. 10. Vaginula and reproductive organs. 11. Perichætial leaves. 12. Stem and branch leaves. 13. Portions of leaf showing the reticulation. 14. A vertical section of the peristome, showing the columella, &c. All magnified except Fig. 1.

2. Schistidium ambiguum (sp. nov.): monoicum, exiguum, pulvinato-cæspitulosum; caule parce ramoso; foliis oblongo-lanceolatis patulo-incurvis apice plus minus cano-piliferis, perichætialibus multo majoribus erectis elliptico-lanceolatis in pilum hyalinum grosse dentatum productis fere suæ longitudinis; capsula immersa oblongo-ovali, operculo convexo-conico brevi-rostrato; calyptra cuculliformi.

Hab. On dry rocks, near Santa Fé, *Mr. Fendler.*

The long, serrated, diaphanous points of the large perichætial leaves, the oblong-oval capsule, the small subconic operculum, and especially the cuculliform calyptra of this species, seem to require its separation from the variable Schistidium confertum, which in all other respects it closely resembles.

Tetraphis pellucida, *Hedw.* Timmia megapolitana, *Hedw.* Weissia controversa, *Hedw.* W. curvirostris, *Brid.* Chiloscyphus polyanthos, *Cord.* Fegatella conica, *Cord.* Fimbriara fragrans, *N. ab E.* Jungermannia barbata, *Schreb.* Madotheca platyphylla, *Dumort.* Marchantia polymorpha, *L.* Radula complanata, *Dumort.* Reboulia hemisphærica, *Raddi.*

3. Fissidens Ravenelii (sp. nov.): dioica; caule declinato simplici minimo; foliis 8–16, (in caule sterili 18–20,) inferioribus parvulis ascendendo sensim majoribus, supremis linearibus acutis conniventibus ad medium usque conduplicatis, lamina immarginata toto ambitu subtilissime denticulata, floralium duplicaturæ marginibus limbatis repando-dentatisque, costa pellucida cum apice desinente instructis, densissime minuteque subquadrato-areolatis, siccis guttulatis; capsula erecta in pedicello sinistrorsum torto ovali-oblonga subpapulosa, peristomii dentibus dense trabeculatis, operculo conico-rostrato, calyptra conica uno latere fissa: flore masculo terminali.

Hab. Detected, March, 1847, by *H. W. Ravenel, Esq.*, on damp ground near the Santee Canal, South Carolina. Also at Society Hill, South Carolina, by *Rev. M. A. Curtis.*

A very distinct and well-marked species, nearly related to F. exiguus, *Sulliv.*, and F. Bloxami, *Wils.* The former of these two species is known by the looser and larger reticulation and the entire margin of its broader leaf; in the latter species, the want of a bordering to the margins of the duplicature, the vanishing of the dorsal ala considerably above the base of the leaf, and the position of the gemmiform male flower, are good distinctive marks. The protuberance of the outer cells of the capsule in the present species does not occur in the others above named. In F. Ravenelii, male and female gemmæ are occasionally met with in the axils of the lateral leaves of what in other species are considered infertile fronds. These gemmæ, upon the decay of the parent stock, become perfect plants. The same mode of propagation occurs in F. bryoides, *Hedw.*

Tab. II. — *Fig.* 1. Plant of the natural size. 2, 3, 4. The same, magnified. 5. Calyptra. 6. Capsule. 7. Tooth of the peristome, and spores. 8. The operculum. 9. A perigonial leaf. 10. Male gemma. 11. Antheridia. 12. A portion of the duplicature of a leaf. 13. Leaf of male gemma. 14. A portion of the lamina of a leaf. — All except fig. 1 magnified.

4. Bryum Lescurianum (sp. nov.): dioicum, humile, laxe cæspitosum, viridi-lutescens (nullo rubore tinctum); caule simplici declinato terra semisepulto ¼–6 lin. longo; foliis erecto-patentibus, inferioribus oblongo-lanceolatis, comalibus perichætialibusque multo longioribus linearibus acuminatis, omnibus apice plus minus serratis medio margine reflexis densius lineari-areolatis, costa valida ad apicem usque producta; capsula ovali-subpyriformi in pedicello ½–1 unciali basi geniculato flexuoso

erecto subpendula, annulo duplici revolubili, operculo subhemisphærico apiculato: planta mascula tenuiore, foliis perigonialibus externis e basi concava subiter linearibus patulis, intimis minoribus ovatis erectis.

B. pulchellum, *Musc. Alleghan. No.* 101.

Hab. Clay banks, in woods, Cincinnati and Lancaster, Ohio; very rare.

The large size of this Moss, its long linear perichætial leaves furnished with a large nerve, the form of its perigonial leaves, the absence of redness in the foliage, and the presence of a conspicuous annulus, separate it from the closely related B. pulchellum, *Hedw.* — Named for my friend, Leo Lesquereux, who discovered the Lancaster locality of this Moss, and detected its specific characters.

5. Dicranum rhabdocarpum (sp. nov.): dioicum, densissime cæspitosum; caule pluries dichotomo ascendente tomentoso-radiculoso; foliis lutescente-viridibus nitidis erecto-patentibus (apicialibus sæpe subhomomallis) strictis concavis, caulinis lanceolatis, comalibus elongato-lanceolatis attenuatis, omnibus costa infra apicem dentatum evanida instructis, areolatione laxa; capsula erecta ovali-cylindrica regulari sicca 5–8 costata exannulata, operculo oblique longirostro: flore masculo in planta tenuiore terminali.

Hab. Santa Fé, New Mexico, *Mr. Fendler.*

In general aspect, D. rhabdocarpum is very like D. scoparium. Its nearest affinity, however, is with D. palustre, *Brid.*, from which it is distinguished by its broader and less attenuated leaves, entirely destitute of transverse undulations, with points more obtuse and strongly dentate, but mainly by its erect regular and prominently ribbed capsule. It is also destitute of the slender upright shoots, with small oval and acute leaves, which occur in D. palustre.

Tab. III. — *Fig.* 1, 2. Female and male plants, of the natural size. 3. Antheridium and paraphysis. 4. Perigonial leaf. 5. Peristome. 6, 7. Capsules. 8. Perichæth. 9, 9. Stem leaves. 10, 10. Perichætial leaves. 11. Cross sections of the same. 12, 13. Portions of the leaf showing the reticulation. — All except fig. 1, 2, magnified.

6. Hypnum Oreganum (sp. nov.): dioicum; caule prostrato parce ramoso; ramis dense pinnatis; foliis e basi lata cordata ovato-longe-acuminatis serrulatis striatis nitidulis tenuissime areolatis, costa sub apice dissoluta; capsula in pedicello muriculato oblonga cernua annulata; operculo conico longe rostrato.

Hab. Oregon, between Puget Sound and Columbia River. (United States Exploring Expedition.)

This species resembles, in many respects, H. crispifolium, from the same locality, as described and figured by Hooker and Schwægrichen. But the opaque subpapillose leaves of the latter species, with a minute subrotund areolation, is a mark abundantly distinctive. H. Oreganum is very nearly related to H. prælongum, from which it differs by its larger size, its more rigid and densely pinnated stems and branches, not compressed, its more striated longer-acuminated leaves, and by the want of a nerve in the perichætial leaves, &c.

7. Hypnum Oakesii, *Sulliv.* (*Gray's Manual of Bot. p.* 673): dioicum; caule prostrato pinnatim ramoso, ramis flexuosis compressiusculis; foliis lanceolatis acuminatis evanidi-costatis spinuloso-dentatis; capsula ovata gibboso-inæquali longi-pedunculata, operculo conico-rostellato.

Hab. On decayed prostrate logs, at the base of the White Mountains, New England, detected by the late *Wm. Oakes, Esq.*

Descr. Planta decumbens, flexilis, viridi-lutescens, nitens, stratum laxe implexum efficiens. Caulis tri-quadriuncialis, tomento radiculoso pluries dichotomo-furcato obsitus, irregulariter pinnatim ramosus, ramis dissitis patentissimis subcomplanatis elongatis flexuosis attenuatis. Folia costa circa medium evanida instructa, minute lineari-areolata, plus minus plicato-striata parcius rugulosa, margine reflexa; caulina concava, lato-ovata, brevius acuminata, patentia vel subsquarrosa; ramea ovalia, longe acuminata, patenti-erecta, apicem versus spinuloso- etiam lacinuloso-dentata. Perichætialia numerosa imbricatim conferta, exteriora reflexo-squarrosa, interiora convoluta erecta capillari-attenuata, omnia denticulata subecostata. Pedunculus e vaginula elongato-cylindrica tenuis, biuncialis et ultra, apice valde arcuatus, in sicco superne sinistrorsum inferne dextrorsum tortilis. Capsula ovata, gibboso-inæqualis, ventricosa, valde pachyderma, deorsum spectans. Peristomii exterioris dentes lineari-lanceolati dense articulati, interioris cilia lanceolata carinata, ciliolis binis interjectis. Annulus exilissimus vix ullus. Operculum conicum brevi-rostellatum. — Flos masculus in planta distincta gemmiformis, axillaris, 8 – 10 phyllus; perigonialia ovata concava ecostata; antheridia 10 –12 longius stipitata, paraphysibus immixtis.

Compared with H. brevirostre, *Ehrh.*, its nearest congener, H. Oakesii has a subpinnate (not subfasciculate) ramification; the branches straight (not incurved); leaves erecto-patent (not squarrose), oval, long-acuminate (not broadly cordate-triangular acuminate, not constricted at upper end of the lamina, nor convolute at the basal angles), strongly and

almost laciniately dentate (not slightly serrulate), with a single costa (not forked). The areolation of the leaf is more linear. The radicular tomentum of stem and branches is more abundant and much more compound in its ramification. The pedicel is longer, &c.

Tab. V. — *Fig.* 1. Plants of the natural size. 2. The same magnified. 3. The peristome. 4. Stem-leaf and cross section. 5. Branch-leaves and cross section. 6. Point of a leaf. 7. Male gemma. 8. Perichæth and vaginula. 9. Perichætial leaves. 10. Capsule and pedicel in a dry state. 11. Operculum. 12. Radicular tomentum with a portion of the stem. All magnified except fig. 1.

3. Sphagnum Torreyanum (sp. nov.): robustum, sordido-fuscescens; caule pedali longiore firmo diviso; ramulis 4–5 fasciculatis inferne remotis superne confertis 12–15 lin. longis 3–4 lin. latis lineari-lanceolatis complanatis plumulosis laxe foliatis; foliis patulis convolutis elongato-lanceolatis apice tubiformibus minuteque eroso-dentatis margine e cellulis exilissimis 4–5 seriatim conflato circumductis serpentino-reticulatis, transversali sectione cellulas linea spirali notatas magnas subrotundas exhibentibus, cellulis chlorophyllosis minutis triangularibus exterius interpositis; fructu ignoto.

Hab. Essex County, New York, *Dr. Torrey.*

This species is at once recognized by its large size, considerably exceeding that of any of its American congeners, and by the color of the whole plant, much like that of S. macrophyllum, n. 18, of Drummond's Southern Mosses.* The arrangement of the cells of the leaf is the same as in S. cuspidatum.†

* This singular Moss is doubtingly referred by Hook. & Wils. to S. macrophyllum, *Brid.*, a species founded on specimens purporting to have been collected near Philadelphia. No American Sphagna known to me accord with Bridel's description of S. macrophyllum, — few present more important discrepancies than the present species. Specimens of it, under the name of S. Georgianum, *Schw. Mss.*, are to be seen in the Schweinitzian herbarium, together with notes made (previous to 1820) by Dr. Torrey, pointing out the peculiar structure of the large cells of the leaf, which are destitute of a spiral fibre and furnished throughout their whole length with a line of unusually large and conspicuous stomata. In the event of Bridel's Moss proving to be different (which is highly probable), Schweinitz's name, "Georgianum," is entitled to adoption.

† The form and relative position, as seen in a cross section of the two kinds of cells comprising the leaf of Sphagnum, will aid in distinguishing the species. In Tab. IV. B., figs. 1, 2, 3, 4, *a* represents a cross section of the large cells, which are always destitute of chlorophyll, having their sides perforated with large circular openings or stomata, and lined (excepting in "n. 18," Drummond, l. c.) with a spiral fibre; *b* represents the same section of the small linear cells containing chlorophyll only. In the North American species, the principal types of structure appear to be the four following. Fig. 1 (tab. l. c.), large circular cells placed in con-

9. Frullania plana (sp. nov.): monoica; caule procumbente vage ramoso vel subpinnato; foliis subimbricatis orbiculatis auriculis parvis galeiformibus æque longis ac latis tectis cauli contiguis; amphigastriis magnis planis rotundis breviter bifidis sinu laciniisque acutis caule triplo latioribus; involucri lobis ovalibus, lobulis amphigastriique laciniis linearibus margine reflexis subrepandis, his utroque margine inferne unidentatis; perianthiis (interdum binatis) in ramulo brevi semi-exsertis oblongo-ovalibus vel subobovatis triquetris dorso sulcatis ventre acute unicarinatis sublævibus: spica mascula globosa.

F. dilatata, *Musc. Alleghan. No.* 269.

Hab. Chimney rocks, on the French Broad River, Eastern Tennessee.

The large plane amphigastrium, the small auricula, the oval perianth, and the considerably larger size of the whole plant, distinguish this species from F. Eboracensis and F. saxatilis. The two latter are probably one and the same species.

10. Frullania Nisquallensis (sp. nov.): digyna; caule procumbente pinnatim decomposito; foliis conferto-imbricatis oblique ovalibus acuminatis apiculatis valde inflexis, auriculis parvis ovali-galeiformibus; amphigastriis obovato-rotundis caule duplo latioribus bifidis sinu laciniisque obtusiusculis margine reflexis; involucri lobulis amphigastriique laciniis linearibus deflexo-falcatis basi cristato-ciliatis; perianthio ovali-obovato subimmerso trigono dorso convexiusculo ventre alte unicarinato.

Hab. Fort Nisqually, Oregon, on the bark of trees. (United States Exploring Expedition.)

In size, color, and ramification, this species is strikingly like F. Tamarisci. But its acuminate, apiculate, and inflexed leaves place it in the same section with F. paradoxa,

tact, with small triangular ones interposed on the outside of the leaf; *S. cuspidatum*, Ehrh.; *S. recurvum*, P. de B.; *S. molluscum*, Bruch.; *S. Torreyanum*, Sulliv. Fig. 2, both kinds of cells as in fig. 1, except that the small cells are placed on the inside of the leaf; *S. acutifolium*, Ehrh.; *S. humile*, Schimp.; *S. tabulare*, Sulliv.; *S. molle*, Sulliv. Fig. 3, large circular or oval cells not in contact, with small oval ones centrally interposed; *S. macrophyllum*, Brid.? *S. squarrosum*, W. & M. Fig. 4, large quadrangular cells in contact only at their outer and inner angles, with centrally interposed small elliptical ones; *S. cymbifolium*, Ehrh.; *S. compactum*, Brid.; *S. sedoides*, Brid.; *S. strictum*, Sulliv.

atrata, Liebmanniana, &c. It is easily distinguishable from them, however, by the amphigastrial laciniæ and lobule of its involucre, which are long uncinate and ciliate-dentate at the base.

11. Riccia lutescens, *Schweinitz!* Fronde viridi-lutescente cavernosa stellatim expansa unciali et majore plus minus dissecta, laciniis subtrichotomis linearibus 1 – 2 lineas latis canaliculatis subplanis subtus convexiusculis radiculosis margine subundulatis apice dilatatis emarginato-bilobis supra turgidis subtus squamatis, squamis transversalibus lunulato-ovatis teneris pellucidis albidis; fructu ignoto.

Schw. Hepat. Amer. p. 26, *n.* 2. — No. 156, R. velutina, *Hook. & Wils.!* in Drummond's Southern Mosses. — *Hook. Icon. Plant. v.* 3, *t.* 249 (excl. plant. fructif.).

Hab. Moist ground and river-banks subject to inundations; Ohio and Southern States, frequent. No fruit has yet been found. The fruit figured in *Hook. Icon. Plant. l. c.*, Mr. Wilson informs me, belongs to R. crystallina.

Tab. IV. A. — *Fig.* 1. Plant, of the natural size. 2. A portion of the epidermis. 3. A cross section of a plane part of the frond. 4, 5. Cross sections of the thickened end of the frond. 6. Longitudinal section of the same. 7. Under side of the same, showing the scales. — Magnified.

W. S. S. del. Tappan & Bradford's lith.

Saskia Pendleii Aut.

Sisudens Ravenelii, Sulliv.

Cladium thabeoguum Auct.

A. *Riccia lutescens. Schweinitz.* B. *Cross sections of leaf of Sphagnum*

Tab. V.

W. SS. del.

Caulerpa Cakesii Sulliv.

VI.

Description of the Observatory at Cambridge, Massachusetts.

By WILLIAM CRANCH BOND.

(*Communicated to the Academy, November 8th*, 1848.)

The Observatory is situated on an eminence elevated about fifty feet above the general plain on which are the buildings of the University, and is seventy feet above the tide-waters of Charles River. This height is found sufficient to give from the dome an horizon almost uninterrupted, to within two or three degrees of altitude, in every direction. The grounds appropriated to it comprise six acres and a half. It is distant three quarters of a mile northwest from University Hall, and three miles and a half west-northwest from the State House in Boston.

Plate I., Fig. 1, is a ground plan of the principal buildings and of those appropriated to magnetic and meteorological purposes; at

A is the equatorial room and pier.

B, The transit-circle room.

C, The prime-vertical apartment.

In the smaller buildings,

a, The situation of the four-foot meridian-transit instrument.

b, The horizontal-force magnetometer.

c, The declination magnetometer.

b' and *c'*, The reading telescopes of the magnetometers.

d, The small altitude and azimuth instrument.

In the construction of the buildings which protect the magnetic instruments, iron has been entirely excluded.

The wires connecting with a system of magnetic-telegraph lines, extending to most of the principal cities of the United States, are brought into the building containing the four-foot transit instrument, at *a*.

e is the situation of the standard barometer, made by Newman.

f, The transit or sidereal clock.

g, The deep well, for temperature of the earth at different depths below the surface.

G is a building used for miscellaneous purposes, chiefly for observation of the magnetic inclination; no iron was used in its construction.

H, The smaller prime-vertical room.

D, The computing room.

E, The observer's dwelling-house.

The western wing, indicated by dotted lines at *F*, *F'*, *F''*, is not yet built.

That part of the main building which is appropriated to the great refractor is thirty-two feet square. The foundations of the walls are of granite blocks, which are from two to three feet in thickness below the surface of the ground. Above, the walls are of brick, laid in cement; on the outside, they are carried up square to the coving. Within, the corners are arched towards the centre in such a manner as gradually to bring the interior to a circular form for the support of the dome, leaving at each of the four corners a recess five feet in depth, with a chord of eight feet four inches in the lower room. In the dome room the recesses are each five feet deep, and the chord is eight feet eight inches. The ceiling of the lower apartment is arched inward towards the pier, but is entirely insulated from it.

Of the four recesses in the dome, the northeastern is occupied by two closets for lamps, books, apparatus belonging to the telescope, &c., and by a balance-chair, which is used as a ready means of conveyance of the observer to and from the rooms below. The southeastern recess contains the machinery for turning the dome. The southwestern is the ordinary entrance, and in the northwestern is deposited the comet-seeker when not in use, with seats, table, &c., for an assistant.

The windows of the dome are provided with iron balconies, which are found to be convenient in using the comet-seeker and other smaller instruments. There is a firm plank flooring to these balconies, with provision for centring the tripod-stand of the comet-seeker, which brings its polar axis at once so nearly to the meridian, (the axis being duly elevated to the altitude of the pole by a spirit-level,) that an object discovered in sweeping may at once be referred to the large telescope. The work of adjustment occupies but a few minutes, and the instrument is readily transferred from one balcony to another. The floor of the dome is supported by an arched frame-work springing from the walls of the building, and secured by a curb encircling, but not touching, the pier.

Plate I., Fig. 2, is a north and south section of the foundations of the walls of the equatorial and prime-vertical rooms, and of their respective piers; at *a a* are the foun-

dations of the outer walls, and at *b b* those of the inner walls; the latter support the dome. The foundation of the great pier is a grouting, composed of cement and coarse gravel, twenty-two feet in diameter at its base, which is twenty-six feet below the natural surface of the ground; the depth of this mass is ten feet. When the grouting had become well consolidated, the pier was commenced with blocks of granite four feet in length by two in thickness.

The pier rises thirty-three feet, to the floor of the dome, in the form of a frustum of a cone, twenty feet in diameter at the base and ten feet at the top. It is surmounted by a capstone of ten feet in diameter and twenty-two inches in thickness. Upon this stands the granite tripod support, of eleven tons' weight; its height is eleven feet. From the top of the tripod to the ceiling of the dome is sixteen feet; the ball on the outside is one foot eight inches above the ceiling; making the entire height from the foundation seventy-three feet. In building the pier, the mason fitted each block to a steady bearing before any cement was inserted.

The form of the granite pedestal, to which the bed-plate of the equatorial mounting of the telescope is attached, will be best understood by reference to Plate II. The base of this pedestal is seven feet one inch on the east and west sides, four feet five inches on the north, and three feet five inches on the south sides. It rests on the cap-stone by three bearings, so situated in regard to the centre of gravity of the whole block and telescope that each bearing supports a nearly equal share of the weight. These bearings are protuberances left when the stone was worked. This method I have adopted with all the piers, as it insures steadiness and admits of easy change of position. Of this we have had an instance in the mounting of the great equatorial, where the azimuth screws came home before the adjustments were completed; by the application of a jack-screw to the base in the line of two of the supports, the whole pedestal and telescope were moved into the required position round the third support as a centre, without perceptible jar or risk of injury.

The piers for the prime-vertical transit, Plate I., Fig. 2, and for the transit-circle, have their foundations of grouting at eighteen feet below the surface. In these, the grouting is inclosed in a pyramidal casing of brick-work, curving inward, and supporting a granite block eight feet long, four feet wide, and twenty-two inches thick; on this block rest the tripod-pillars supporting the Ys of the instruments.

The dome covering the great equatorial is a hemisphere of thirty feet interior diameter, framed with stout ribs of plank, and covered with copper on the outside, on a sheathing of thin boards. The ceiling within is of wood, the air being allowed to circulate between the inner and outer coverings. We have been gratified to find that the internal temperature quickly approximates to the external, during sudden changes.

A circle of granite surmounts the walls. On this is secured an iron plate ten inches in width, hollowed in the middle; a similar track is laid on and bolted to the under section of the dome; and between them are placed eight iron spheres, eight inches in diameter, upon which the dome rolls.

The openings for the telescope are nearly five feet in width, extending from three degrees beyond the zenith to as many below the horizon, the entire aperture being available. The shutters are divided into three compartments, the two upper moving on an iron railway, with rollers at distances of a foot apart, to relieve the friction. The shutters are worked by means of endless chains, acting in toothed wheels, turned by a crank and pinion; the leading of these chains, as well as the position of the crank, is shown in Plate V., Fig. 1. The third and lowest division of the shutters is subdivided into three parts, each of which is counterpoised by weights traversing within the dome, and acting in the same manner as those of ordinary window-sashes. The frames of all are of ash, covered with copper sheathing, and they are perfectly weather-proof. The machinery occupies but little room, and the whole is easily managed.

Plate V., Fig. 1, is a section of the dome, intended to illustrate the arrangement for working the shutters. At *a*, *b*, *c*, *d*, they are represented as closed; *a* and *b* are similar, each being nine feet long. The frames are of two-inch-square ash; there are in each nine cross-bars, besides the end-pieces, and the whole is covered simply by copper, painted, in order that they may be as light as possible consistently with the requisite strength.

A transverse section of *a* is shown in Fig. 2, where, at *a' a'*, &c., the shutter bears, by iron rollers inserted into the framework of shutters, upon the dome; and at *b b'*, on each side, near the ends, are like rollers, to relieve the friction which might take place during high winds, causing a lateral pressure.

In Fig. 1, *h h*, &c. shows the track of the chains by which the shutters are raised and lowered. At *f* there is an iron arm, which is secured to the upper shutter, and projects downwards within the middle one. To this arm one end of the chain is secured, and leads forward from *f*, passes round a pulley at *g*, and then back over pulleys at *h h*, &c., keeping nearly the curvature of the dome, and downward to *i*, where it is received on a toothed pulley of seven inches diameter, like that shown in Plate IV., Fig. 2, letter *i*. The chain then leads upward, supported in place by rollers, in the direction *h h*, until it reaches *f*, where it is riveted to the other end, thus forming a continuous chain. It will be borne in mind, that there is precisely a like arrangement of chains and pulleys for each side of each shutter, and by reference to the plate it will be understood that, on turning the crank at *i* forward, the shutter will be opened; if turned backward, the shutter will be closed.

At *k k*, Plate V., Fig. 1, are two iron rails secured to the outside of the dome; they receive the shutter *a* when it is rolled back; there are separate rollers for this track, seen at *c' c'*, &c., Fig. 3. They have proved safe guides, when the dome has been much encumbered with ice and snow. Fig. 3, at *a' a'*, &c., are iron rollers about one inch in diameter; they bear the weight of the shutter, resting on the frame of the dome at the sides of the opening.

The arrangements for the middle shutter are similar to those for the upper one; the only difference consists in placing the iron arm to which the chain is fastened at the upper, instead of the lower, part, and leading its chains down to the pulley at *o*, Fig. 1. The chain is then carried up along the edge of the opening, round the ceiling of the dome, and down to *i*, where there is another toothed pulley to receive it.

Plate V., Fig. 1, at *n* is given an edge view of the iron frame supporting the wheels and pinions for moving the chains of the shutters. This frame is six feet two inches wide by twelve feet high, and is firmly bolted at its upper part to the dome, at *p*. The upright part is of bar-iron three inches wide by three quarters of an inch thick; the cross-bracing bars are two inches wide by half an inch thick. At *q* are bolt-holes, intended for attaching the observing-chair to the frame to be carried round with the dome. It is not, however, used, as the driving-wheel of the chair is found to be more convenient, and brings this motion immediately under the control of the observer.

The axles of the wheels at *i* are six feet long, and near the ends have toothed pulleys, like the one shown in Plate IV., Fig. 2, letter *i*. There are four of these pulleys, each of them seven inches in diameter. The axle carrying the chain of the upper shutter is a hollow cylinder, and the axle of the lower shutter passes through it. The power-gearing of both is on the right-hand side of the frame, and consists of two iron wheels (one for each axle) of eleven inches in diameter, and a double-headed pinion of three inches in diameter. To the pinion-arbor is attached a crank of one foot purchase. The pinions have an end motion, that they may readily be changed from one wheel to the other, the same crank moving either shutter up or down.

For turning the dome, a series of toothed iron plates, with a curvature of fourteen feet nine inches radius, is fastened to its lower section, forming a contrate wheel of twenty-nine feet and a half in diameter. Into this is geared a wheel four feet in diameter, acting vertically in the recess at the southeast corner. The weight of the dome is about fourteen tons, and it can be moved through an entire revolution by a single person in thirty or forty seconds.

In addition to the security resulting from the weight of the dome constantly tending to bring the balls to the middle of the curved rail, and consequently to produce a coinci-

dence of the centres of the upper and lower circles, eight iron braces are fastened to the wall, seen in Plate II., and present rollers of three inches in diameter to the interior of the dome. These are designed to prevent an accumulation of oscillation during high winds, rather than to act as guides on ordinary occasions. The form of these and of a part of the machinery is exhibited in Plate II.

Plates III. and IV. represent perspective and sectional views of the observing-chair.

Plate IV., Fig. 1, at *a a* is seen a portion of the wooden frame; *b b* is a section of the box confining the counterpoise weight *c*, attached to the chain *d d*, which passes over a pulley at *f*, and is secured to the chair at *e*. There is the same arrangement on the opposite side. The two balance-weights exceed the weight of the chair by one hundred pounds. The chain *g g* is attached to the upper extremity of the iron rail at *h*. It passes round the toothed wheel *i*, and then upwards over the plain iron pulley at *k*, thence downwards till it is made fast to the arm of the axle of the *tension weight*, the purpose of which is to preserve constantly a safe gearing of the chain in the toothed wheel *i*. The action of the chain and pulleys is seen in Fig. 2.

The chains, side and edge views of which are given in Fig. 3, are made after the same manner as the fusee-chain of a watch; the links are each an inch and a half long, and, being all struck out in the same die, are uniform in size. The teeth in the wheel *i* have spaces corresponding to a link of the chain, and are cut down in the middle, as seen in Figs. 2 and 4, to admit the inner connecting link, so as to allow the outside links of the chain to fall into the spaces between the teeth of the wheel, giving a perfectly safe holdfast for the chain.

In Fig. 4 the wheel for elevating the chair is seen attached to the shaft *m*; this shaft is turned by means of the endless screw *n*, Fig. 5, working in the wheel *o*, as seen in Figs. 4 and 5. On the top of the shaft *p*, Fig. 5, is a round table, *q*, serving as a convenient stand for the observer's note-book, &c.

It will be seen that by turning the handle *r*, motion will be communicated to the shaft *m*, which is attached to the seat of the chair in such a manner as to elevate or lower the chair as occasion may require. The endless screw *n* was selected for giving the motion, in preference to any form of ratchet or lever work, for its security against the accidents to which the latter are always liable.

In order to make the eye of the observer move in a circle concentric with that described by the eye-piece of the telescope, and at the same time to preserve the horizontal position of the seat, two curved iron rails are secured to the frame on each side of the chair. On these rails the chair moves, being supported in front and back on rollers, at *s s* and *t t*. To fulfil the required conditions, the radius of curvature of each rail was

made nearly equal to the radius of the circle described by the eye-piece of the telescope. The centre of curvature of the front rail is placed, relatively to the centre of motion of the telescope, as the eye of the observer is to the axis *k*, Fig. 1 ; the upper part of the rail being carried back far enough not to interfere with the motions of the telescope. The centre of curvature of the back rail is placed relatively to the centre of the front rail as the axis *u u* is to the axis *k*.

The geometrical principle made use of may be illustrated by describing three circles of equal radii from the apices of any triangle, *a b c*, as centres; the relative positions of *a*, *b*, and *c* being those of the observer's eye, and the axes *k* and *u u*.

Plate IV., Fig. 6, shows the arrangement for altering the position of the part of the chair supporting the head and back. Attached to the chair at *x*, Fig. 1, is a box for holding the different eye-pieces.

To facilitate the horizontal motion of the chair, two rails, seen in Plates II. and III., of round inch-iron are let into the floor of the dome; the inner track is on a radius of seven feet four inches, and the outer of twelve feet four inches. On these rails the whole frame moves on four wheels, with grooves adapted to the rail. A driving-wheel, seen in Plate III., at the back part of the frame, runs on the outside track. It has a double groove, one fitted to the track, and the other with spurs to prevent the slipping of a rope which passes round it. This rope leads over pulleys on the top rail of the frame, and passes down within reach of the observer and round a pulley fastened to the lower front rail of the frame. To this pulley is attached a spiral spring, to preserve an equable tension on the rope.

This contrivance enables the observer, without leaving his seat, to move the chair round on the railway, while at the same time he is able to adjust his position in altitude. Whatever may be the position of the telescope, a proper movement of the driving-wheel and of the endless screw brings the observer's eye to the eye-piece of the telescope. The machinery above described is found on trial to fulfil perfectly the objects for which it was designed, giving the observer entire command over his position, and combining security with ease and steadiness of motion.

The Great Refractor. — This instrument was made at the establishment of Messrs. Merz & Mahler, at Munich, Bavaria. The extreme diameter of the object-glass is fifteen and a half English inches. The effective aperture is fourteen and ninety-five hundredths inches, the solar focus being twenty-two feet six inches. From the outer surface of the object-glass to the intersection of the declination-axis is thirteen feet seven inches. From the intersection of the declination-axis to the solar focus is eight feet eleven inches.

The centre of motion of the whole instrument is twelve feet nine inches above the floor of the dome. The entire length of the declination-axis from its junction with the bed-plate of the tube is six feet; the axis is of steel, or steel-cased, and its bearings are three feet eight inches apart, and are relieved by four friction-wheels three and a half inches in diameter.

The declination-circle is twenty-six inches in diameter, reading by four verniers to four seconds of arc. The polar axis is also of steel; its length, from the end-bearing of its lower pivot to its junction with the bed of the declination-axis, is three feet ten inches, and its bearings are two feet eight inches apart. The upper bearing is relieved by two friction-wheels seven inches in diameter, attached to the short arm of a lever, which moves on a steel pin below the axis; the longer arm of the lever passes through the upright part of the cradle of the lower axis, and supports at its forked extremity the balance-weight of the polar axis. The lower or southern end of the axis rests against a plate of hard metal, which is capable of adjustment by means of a stout capstan-headed screw.

The hour-circle is eighteen inches in diameter, and reads by two verniers to single seconds of time.

The cradle in which the polar axis rests is of brass, four feet ten inches long by nine broad, and is four inches deep. This is secured to the bed-plate by twelve large steel screws. The bed-plate itself is attached to the stone tripod by six screw-bolts.

The tube of the telescope is of wood, veneered with mahogany and polished on the outside. Within, it is lined with paper, and is strengthened by iron diaphragms. The flexure of the tube is counteracted, and its balance preserved, by two brass rods seventeen feet in length, having at their extremities nearest the eye-end brass spheres filled with lead, eight inches in diameter. These rods turn on a universal joint near the middle or centre of motion, and oppose the influence of gravitation on the longer and heavier part of the tube in every position.

The focal length of the finder telescope is forty-five inches, and its aperture three inches.

Sidereal motion is communicated to the telescope by means of clock-work, regulated by the friction of centrifugal balls. There are eighteen eye-pieces of the following description. The powers given I have determined by means of a Dolland dynameter.

Annular Micrometers.

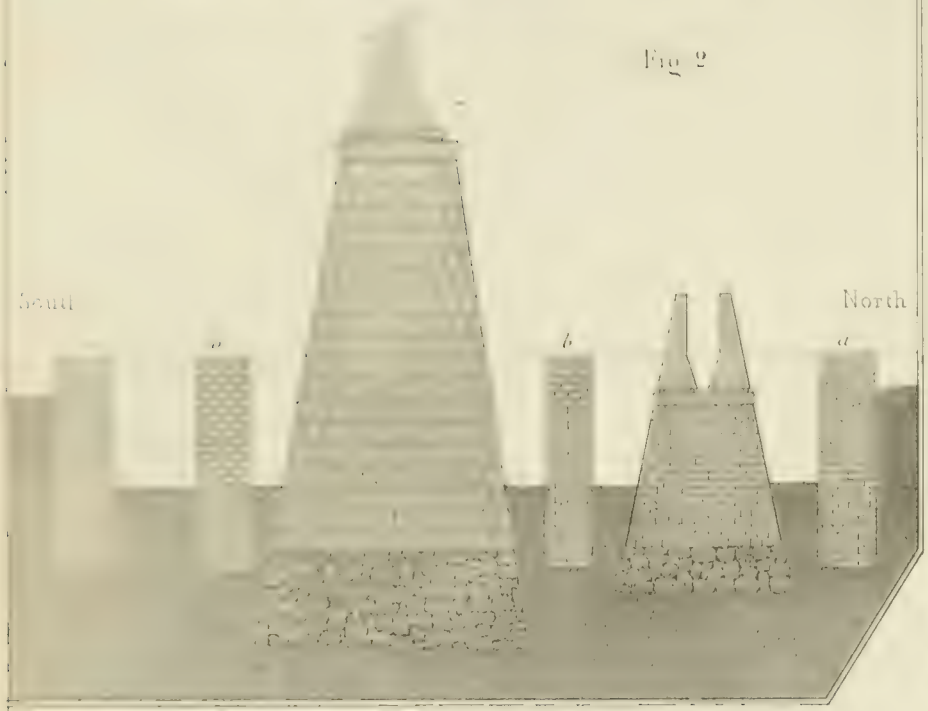
No. 1.	Power,	103.
2.	"	172.
3.	"	229.
4.	"	373.

Plain Eye-pieces.

No. 1.	Power,	222.
2.	"	333.
3.	"	505.
4.	"	767.
5.	"	1118.

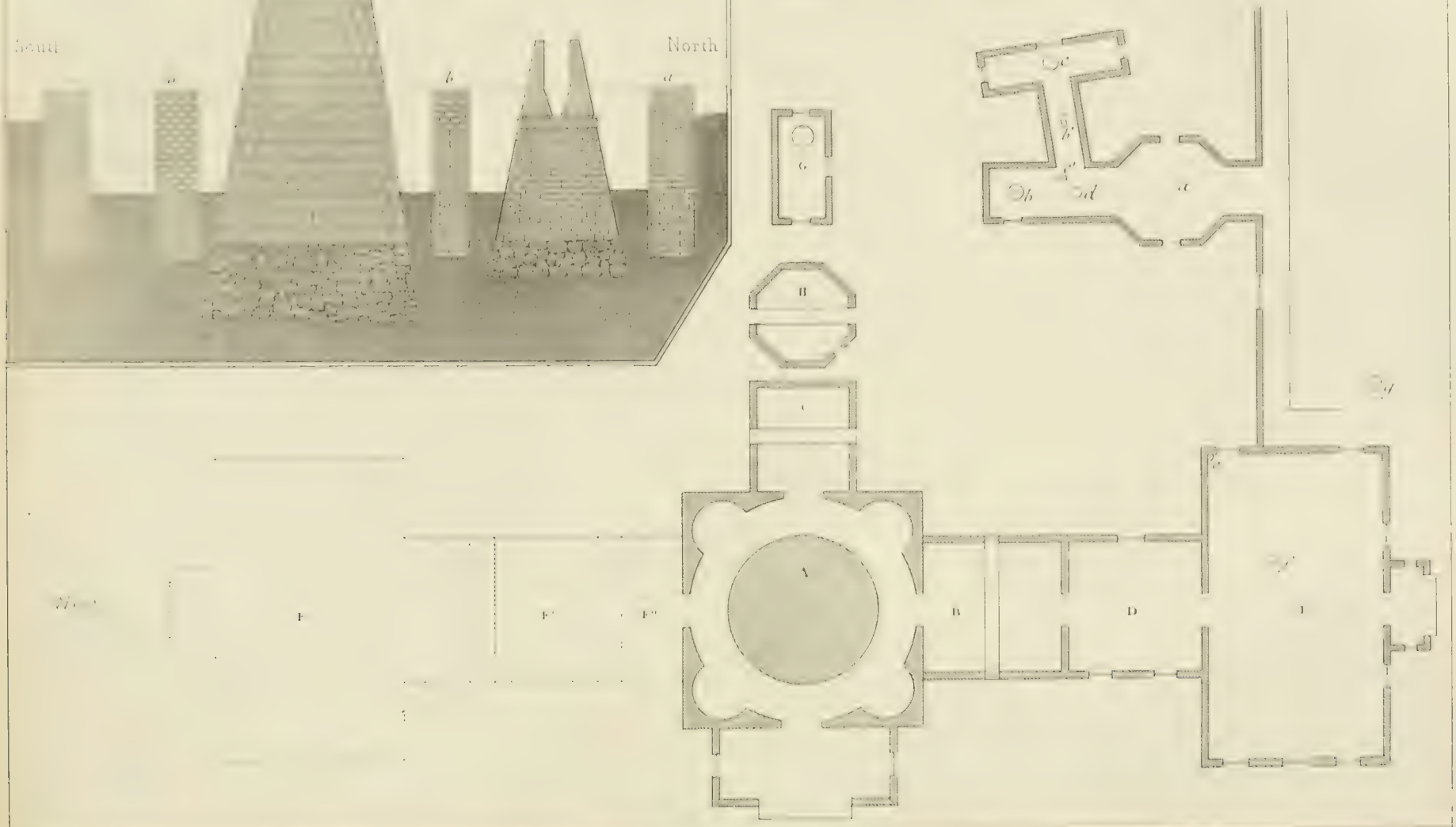
Scale of Feet
0 10 20 30 40 50

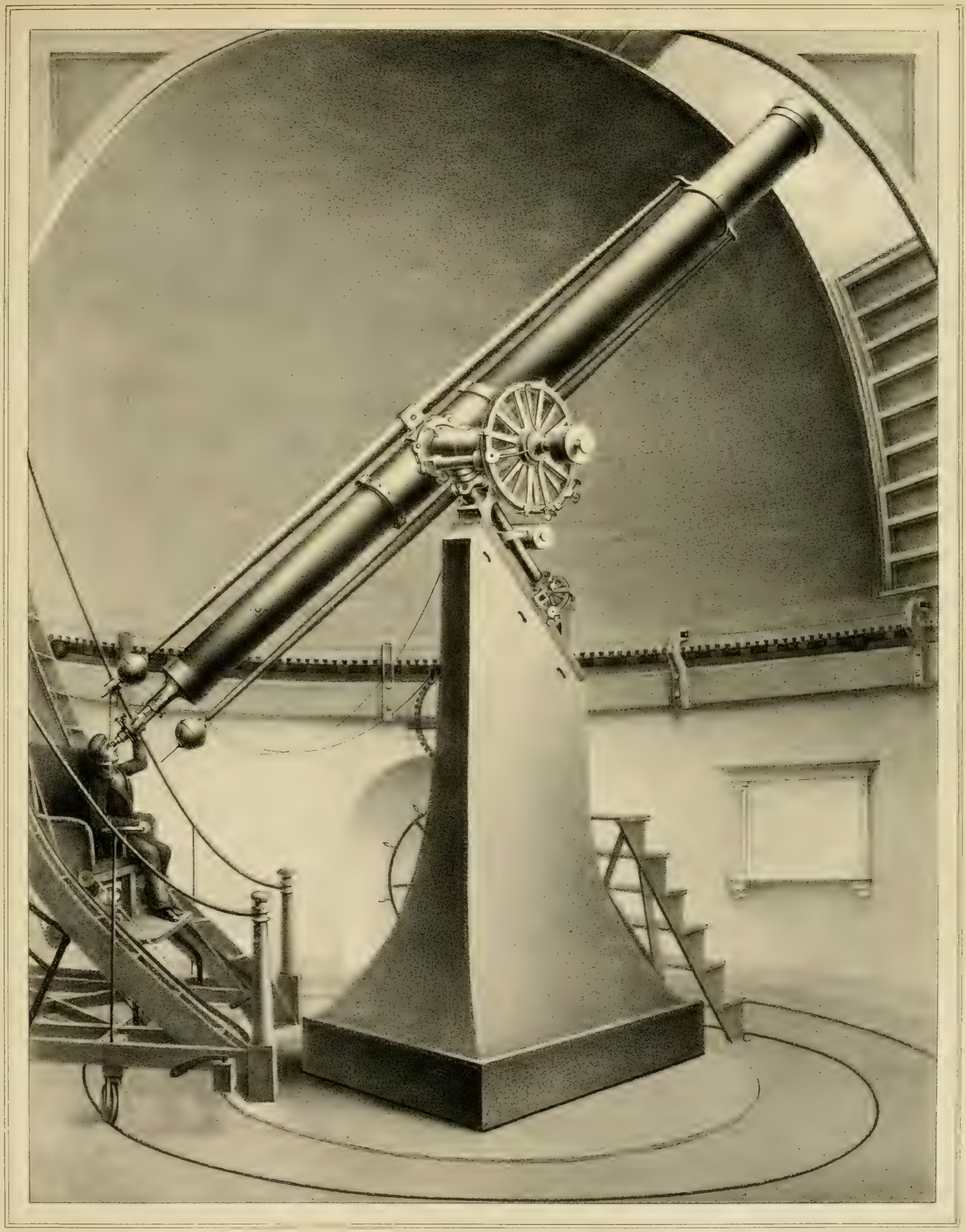
Fig 2

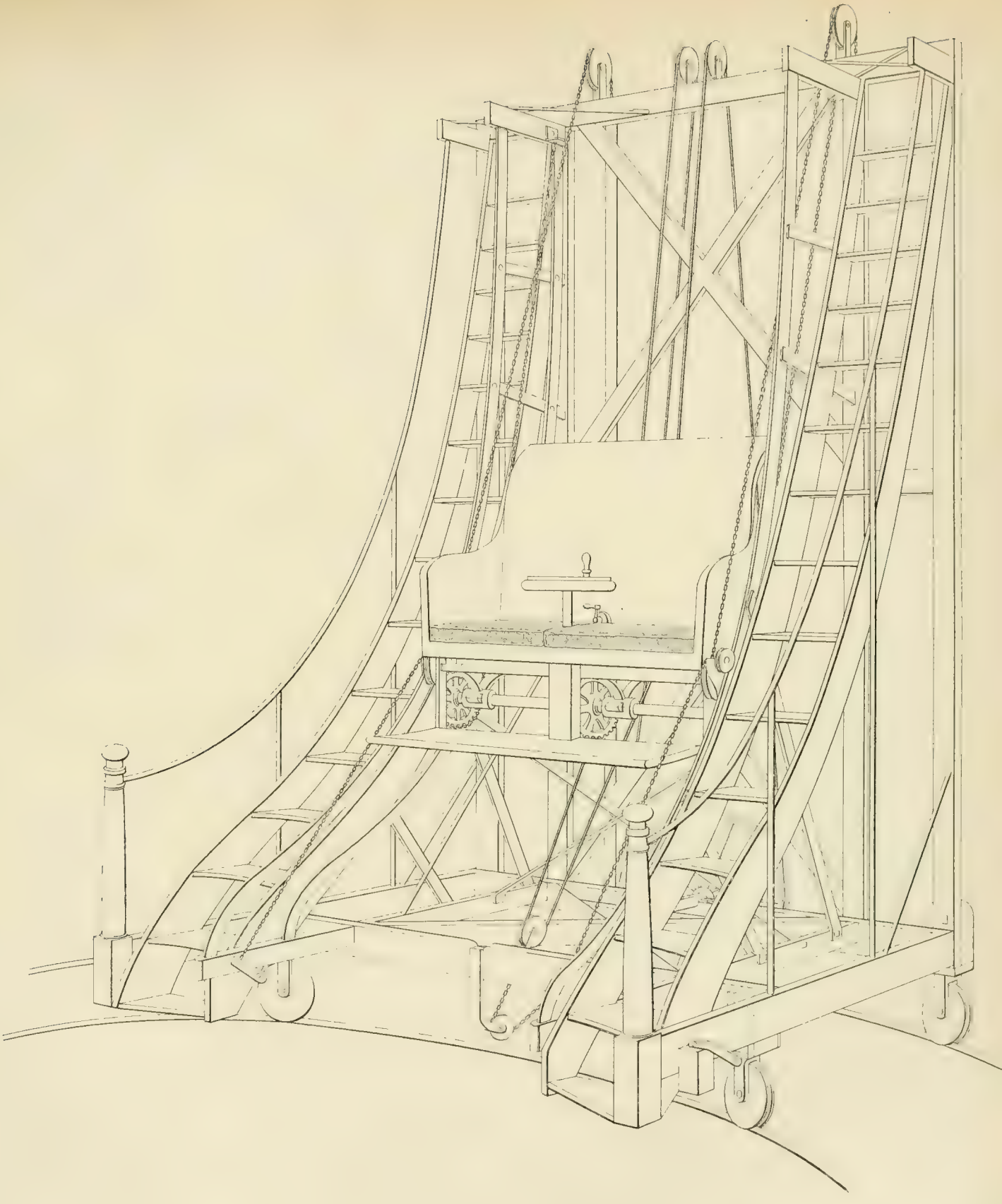


Scale of Feet
0 10 20 30 40 50

Fig 1







THE OBSERVER'S CHAIR.

Fig. 1.

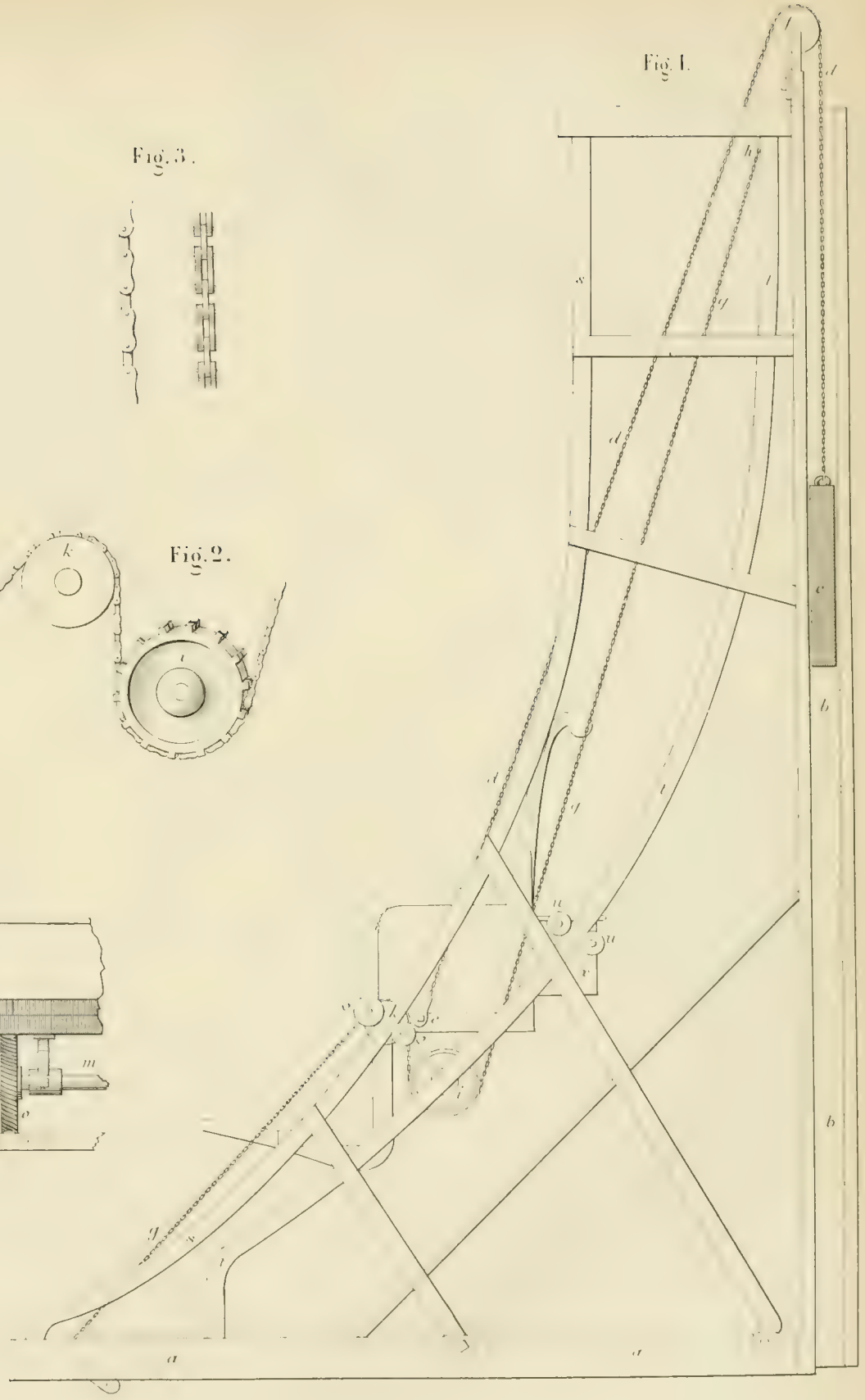


Fig. 6.

Fig. 3.

Fig. 5.

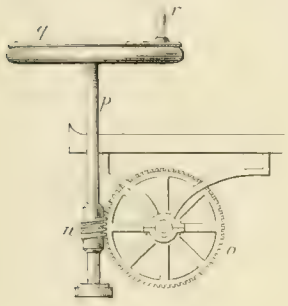


Fig. 2.

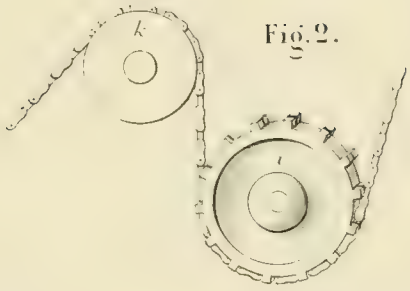
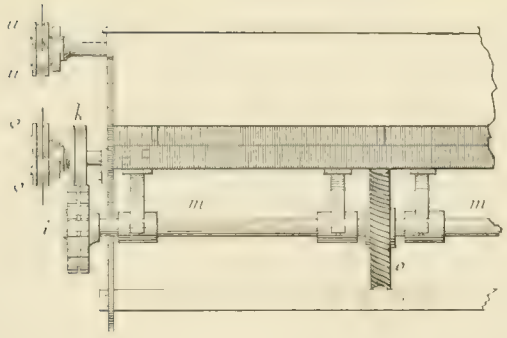
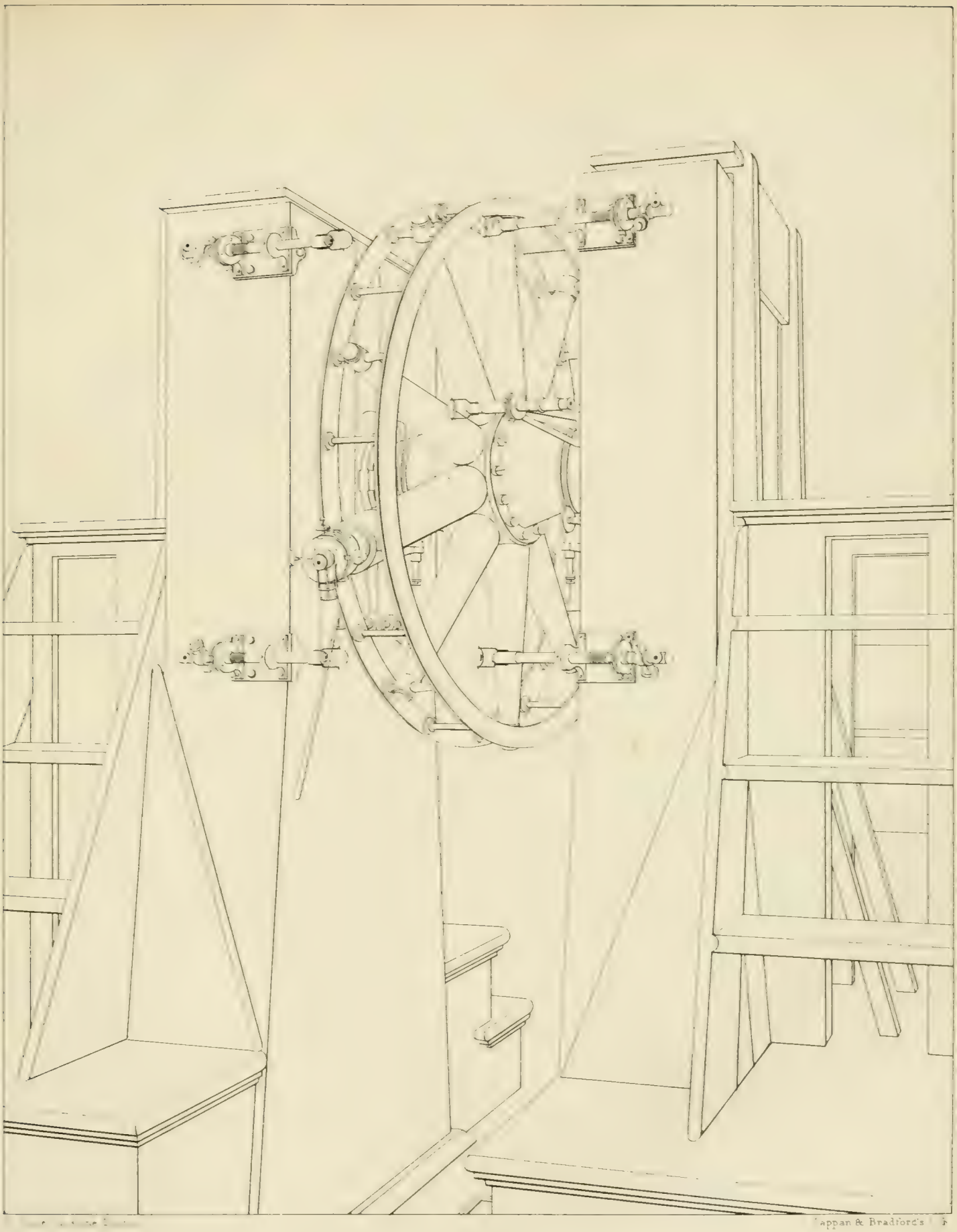


Fig. 4.



SECTION & DETAILS OF THE OBSERVER'S CHAIR.

Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4
Fig. 5
Fig. 6



Tappan & Bradford's

TRANSIT CIRCLE.

Spider-line Micrometers.

No. 1.	Power,	141.	Field of view,		12′.
2.	"	206.	"	"	9.
3.	"	316.	"	"	7.
4.	"	401.	"	"	4.
5.	"	688.	"	"	3.
6.	"	861.	"	"	2.
7.	"	1243.	"	"	2.
8.	"	1561.	"	"	1.
9.	"	2004.	"	"	1.

The position-circle of the micrometer at the divisions is seven inches in diameter, reading by two verniers to single minutes. The head of the micrometer-screw is divided into one hundred parts, each being of the value of one tenth of a second of arc nearly. The equality of the values of the revolutions and half-revolutions of the screw has been examined over a space of fifty revolutions by transits of Polaris.

Revolutions in different parts of the screw are found to be sensibly equal, and no irregularities were detected beyond the limits of errors to which the determination was liable.

The values of a revolution of the screw for different temperatures are as follows: —

Temperature Fahrenheit,		0°.	Value of r =	9.771.
"	"	+16.	"	.797.
"	"	+61.	"	.801.
"	"	+82.	"	.813.

Final value of one revolution: —

$$r = 9.''800 + 0.''00026\ (t° - 50°).$$

The dilatation of the screw seems to have greater effect on the value of r than the increase of focal distance, arising from the expansion of the object-glass.

The workmanship of the machinery of the mounting is creditable to the makers, and the general plan combines strength with simplicity and convenience of management. The friction of the various actions is greatly relieved by the judicious arrangement of counterpoises and friction-wheels, so that the whole is moved with great ease by a single finger, though weighing about three tons.

It has been objected to the German form of mounting a telescope equatorially, that it requires reversal whenever the object under examination crosses the meridian. This is felt as a practical inconvenience with the Cambridge equatorial only in small zenith distances, since in most instances the telescope passes the meridian by more than an hour of right ascension, and always by more than two hours in southern declinations.

There are, however, one or two points in which the instrument is susceptible of improvement. The arrangement of the divisions of both the declination and hour-circles is awkward, and the reading off of both attended with needless trouble. The screw for adjusting the focus of the eye-pieces has too fine a thread and is inconveniently situated. The clock for regulating the movement of the telescope is disproportionate to the other parts of the instrument, and in cold weather requires frequent adjustment.

In every other particular, I believe we have reason to be perfectly satisfied. The object-glass, by far the most important part of the instrument, is an admirable specimen of the skill of Messrs. Merz & Son. Its defining excellence is such, that powers of from seven to twelve hundred are habitually used in the measurement of double stars. On rare occasions, a power of two thousand has shown well the disks of Neptune and of the satellites of Jupiter. With powers of seven and eight hundred, we have separated the disks of stars whose measured distance has proved to be 0.″3.

With a power of one hundred and forty-one, the sixth star of the trapezium of Orion is distinctly separated from its bright companion. The fifth star we have seen after sunrise. This star is classed as of the thirteenth magnitude.

The satellites of Neptune and the inner and eighth satellites of Saturn are seen steadily, as well as the edge of its ring, at what is called its disappearance.

I consider the smallness of the disks of the stars which are given by this object-glass an indication of remarkable excellence. Soon after mounting the telescope, we had several caps made for reducing the aperture. These we have since entirely discarded, having found on trial that the whole aperture may be used without injury to the definition.

The Transit Circle. — The *meridian-circle* in some respects resembles the circle designed and made by Troughton for the Imperial Academy at St. Petersburg, which ultimately, in the hands of Mr. Groombridge at Blackheath, rendered such important services to astronomy. Many improvements have, however, been introduced. To the Groombridge circle there were four reading microscopes, which were supported by long brass arms. The Cambridge circle has eight micrometer reading microscopes, and these are attached immediately to the granite pier. For the plumb-line, a striding level is substituted, which, combined with the method of reflection from quicksilver at the nadir point, affords an independent means of ascertaining the amount of collimation of the mid wire without reversal of the pivots; there is, however, apparatus for reversing the instrument.

Beside the usual mode of illuminating the field through the axis, there are facilities for illuminating the wires in a dark field. The eye-piece is provided with two micrometers, one having a vertical and the other a horizontal movement; double friction-wheels,

with spiral springs, to relieve the pressure of the pivots upon the Ys, have been applied instead of the single wheel; abutting pieces, with double thumb-screws, are placed at the ends of the pivots on the bearing-plates, to secure the axis against lateral motion. The frame of the instrument appears simple, firm, and symmetrical. The circles are four feet in diameter, being cast in one piece, and are both graduated on silver, from 0° to 360°, into five-minute spaces.

The telescope has an object-glass, by Merz, of four and one eighth inches aperture, and sixty inches focal length. The eight reading microscopes serve to bisect diametrically both circles; the five-minute spaces of the limbs are subdivided by the micrometers, a single division of the micrometer-head being equal to one second of arc, and may be read by estimation to two tenths of a second.

The length of the axis, between the shoulders of the pivots, is two feet two inches; the pivots are of steel, two and a half inches in diameter, and the same in length; the bearing-plates of the Ys are eight inches broad and twelve inches long; they are secured to the granite piers by screws passing into nuts, which are firmly imbedded with plaster of Paris in the stone.

The friction-wheels, for relieving the pressure of the axis-pivots upon the Y's, are supported by plates, eleven inches and a half by twelve inches, secured to the piers. These plates carry also the screw of slow motion, which is brought into action by means of a clamp embracing the axis of the telescope. Plate VI. is a perspective view of the meridian-circle, mounted on its piers. The room in which it is placed is seventeen by eighteen feet, and twelve feet high. A description of the shutters of the roof in this room will answer for those of the prime-vertical, as they differ only in position.

Plate V., Fig. 4, is a sectional view of the southern shutter. It extends down about two feet on the north side, and is quite close at the apex, *r*. The movement is horizontal, east and west, on rollers running on iron rails laid on the outside and inside of the roof of the building, the bearings being at *r r r* and *t*. At *s* is a strong iron arm, secured to the shutter; the form and action of this iron arm are better seen in fig. 6; it is made fast to the shutter at *u*. At the end, *v*, a rope is fastened and carried first forward toward the opening, passing round the pulley *x*. It then leads back, over the pulley *y*, down to *z*, where it is secured to the wheel *z*. The diameter of this wheel is proportioned to the distance which the shutter requires to be moved, so that a turn and a half of the crank *z'* suffice to open or close the shutter. The other part of the rope, from *v*, leads over the pulley *y'*, and is wound round and fastened to the wheel *z*, in the opposite direction; so that the turning of the crank *z'* in one direction serves to open, and in the other to close, the shutter.

Fig. 5 of the same plate is a section of the northern shutter, where the same parts, acting in a similar manner, are indicated by the same letters, accented. This part moves independently of the southern, and has a like arrangement for opening and closing, only that the two open in opposite directions, one east and the other west.

This plan has been found to answer completely the intended purpose. The shutters are perfectly weather-proof, and the division into two parts, by keeping the northern part closed during high and cold northerly winds, affords comfort to the observer and protection to the instrument. The southern opening has a range of 110°.

The lesser equatorial is mounted in a detached building, situated about two hundred feet northwest of the great central pier. This building is of wood, and twelve feet in diameter; it turns on iron balls of six inches in diameter, moving in hollow, cast-iron ways. It is turned by hand, without any machinery. The telescope has an object-glass of four and an eighth inches diameter, by Merz, and sixty inches focus, and is provided with spider-line, double-image (Airy's), and annular micrometers. The mounting is by Simms, and its support a granite pedestal entirely isolated from the building.

The comet-seeker is by Merz, and is equatorially mounted after the German fashion. It is portable, and is used from the balconies of the dome; the aperture of its object-glass is four inches, and its field of view four degrees.

A transit instrument of four feet, made by Troughton & Simms, is mounted on granite piers, in the meridian at *a*, Plate I., Fig. 1. It has also been occasionally used as a prime-vertical instrument on the pier in the room *c*, an extra pair of Ys being provided for it for that purpose.

An eighteen-inch variation transit, or altitude and azimuth instrument, is placed on a wooden tripod at *a*. This is used in the adjustment of the magnetic apparatus, which consists of a Lloyd declination-magnetometer at *c*, and a horizontal-force bifilar magnetometer at *b*.

Besides the above, the Observatory is furnished with four four-foot achromatic, and two reflecting telescopes, the necessary apparatus for meteorological observations, an astronomical clock, and several sidereal chronometers.

It is proper to add, that the necessary funds for the establishment of the Observatory, and for its permanent endowment, have been furnished mainly through the liberality of private citizens of Boston and its vicinity. The expense of the buildings and grounds has been defrayed by the University.

VII.

On some Applications of the Method of Mechanical Quadratures.

By GEORGE P. BOND.

(*Communicated to the Academy, May 29th*, 1849.)

It is proposed, in this communication, to apply some of the known formulæ of the method of quadratures to several astronomical problems of interest, where, under certain conditions, their employment tends to accuracy and simplicity in computation, and offers methods entirely independent of those in common use.

I. Let A_0, A_1 ..... A_n, be a series of values of any function of which t is the independent variable. For convenience of expression, we may call t the time for which A_0, A_1 ..... A_n, are given. Supposing A to be computed numerically for the successive values of t, $t=0$, $t=\tau$, $t=2\tau$ ..... $t=n\tau$, τ being the equal interval between each succeeding value of t, and n the number of times for which A is found. We may then arrange t and A with its first, second, &c. differences, Δ^1, Δ^2, Δ^3, &c., in vertical columns, as follows: —

$$
\begin{array}{llllll}
t=0 & A_0 & & & & \\
 & & \Delta^1_0 & & & \\
t=1\tau & A_1 & & \Delta^2_0 & & \\
 & & \Delta^1_1 & & \Delta^3_0 & \\
t=2\tau & A_2 & & \Delta^2_1 & & \Delta^4_0 \\
 & & \Delta^1_2 & & \Delta^3_1 & \\
t=3\tau & A_3 & & \Delta^2_2 & & \\
 & & \Delta^1_3 & & & \\
t=4\tau & A_4 & & & &
\end{array}
\qquad (1)
$$

It is plain that, as τ is decreased, $\frac{\Delta^1_0}{\tau}$, $\frac{\Delta^1_1}{\tau}$, &c., will approximate to the values of the first differential coefficients of A at the times $t=\frac{1}{2}\tau$, $t=\frac{3}{2}\tau$, &c., which they will accurately represent as long as the *third* differences of A, or Δ^3_0, Δ^3_1, &c., are insensible. If, then, we know A_0, and also the first differential coefficients of A for $t=\frac{1}{2}\tau$, $t=\frac{3}{2}\tau$, &c., these multiplied by τ, and substituted for Δ^1_0, Δ^1_1 ..... Δ^1_n, in (1), will give, by

continued addition, $A_1, A_2 \ldots\ldots A_n$. And, in this manner, in the case supposed, that is, of $\Delta^3_0, \Delta^3_1 \ldots\ldots \Delta^3_n$, being insensible, we shall obtain the total change of A between the limits $t=0$ and $t=n\tau$.

Before correcting this process, in order to take account of the third and higher orders of differences, it will be well to observe, that the effect of increasing n, or the number of intervals into which the whole time is divided, is to diminish Δ^2, Δ^3, &c., relatively to Δ^1, nearly in the proportion of the corresponding powers of n. Thus, when the number of intervals is doubled, Δ^1 has about one half its previous value, Δ^2 one quarter, Δ^3 one eighth, and so on. The intervals, therefore, can always be diminished so as to make Δ^3 insensible compared with Δ^1. But it is better, in most cases, to allow Δ^3 to be a small quantity, and to correct A for its influence, and for that of higher orders of differences.

Arranging the numerical values of the first differential coefficients * of A, represented by V, with their differences, D^1, D^2, &c., in vertical columns, as has already been done with A, we have, taking for convenience τ for the unit of time, or $\tau=1$: —

(2)
$$\begin{array}{lllllll}
t=-\frac{3}{2} & V_{-\frac{3}{2}} & & & & & \\
 & & D^1_{-\frac{3}{2}} & & & & \\
=-\frac{1}{2} & V_{-\frac{1}{2}} & & D^2_{-\frac{3}{2}} & & & \\
 & & D^1_{-\frac{1}{2}} & & D^3_{-\frac{3}{2}} & & \\
=+\frac{1}{2} & V_{+\frac{1}{2}} & & D^2_{-\frac{1}{2}} & & D^4_{-\frac{3}{2}} & \\
 & & D^1_{+\frac{1}{2}} & & D^3_{-\frac{1}{2}} & & \\
=+\frac{3}{2} & V_{+\frac{3}{2}} & & D^2_{+\frac{1}{2}} & & & \\
 & & D^1_{+\frac{3}{2}} & & & & \\
=+\frac{5}{2} & V_{+\frac{5}{2}} & & & & &
\end{array}$$

If we put a, b, c, &c., for the first, second, &c. differential coefficients of A_0, we shall have at any time $t=n\tau=n$,

(3) $$A_n = A_0 + a\,t + \tfrac{b}{1.2}\,t^2 +, \text{ &c.}$$

(4) $$V_n = a + b\,t + \tfrac{c}{1.2}\,t^2 +, \text{ &c.}$$

By making successively $t=\frac{1}{2}$, $t=\frac{3}{2}$, &c., in the expression for V_n, we obtain by elimination a, b, c, &c., in terms of V and numerical coefficients, and these substituted in the value of A_n give

(5) $$\Delta^1_n = A_{n+1} - A_n = V_{n+\frac{1}{2}} + \tfrac{1}{24}\,D^2_{n-\frac{1}{2}} - \tfrac{17}{5760}\,D^4_{n-\frac{3}{2}} + \tfrac{367}{967680}\,D^6_{n-\frac{5}{2}} -, \text{ &c.}$$

And thence

(6) $A_n - A_0 =$ sum of all the quantities $V_{\frac{1}{2}} \ldots\ldots V_{n-\frac{1}{2}} + \tfrac{1}{24}\left(D^1_{n-\frac{1}{2}} - D^1_{-\frac{1}{2}}\right) - \tfrac{17}{5760}\left(D^3_{n-\frac{3}{2}} - D^3_{-\frac{3}{2}}\right) + \tfrac{367}{967680}\left(D^5_{n-\frac{5}{2}} - D_{-\frac{5}{2}}\right) -$, &c.

* The usual notation for first and second differential coefficients is not employed in this paper, from its resemblance to that here used for finite differences.

It will be noticed, on reference to (2), that the differences $D^2_{n-\frac{1}{2}}$, $D^1_{n-\frac{3}{2}}$, &c., are on the same horizontal line with $V_{n+\frac{1}{2}}$. The intervals may usually be taken small enough to enable the computer to neglect differences of V of a higher order than the second. Then the total variation of A between the limits for which V is known is the sum of all the values of $V + \frac{1}{24}(D^1_{n+\frac{1}{2}} - D^1_{-\frac{1}{2}})$.

Where the intermediate values of A are required, Δ^1_0, Δ^1_1, Δ^1_2 ..... Δ^1_{n-1}, are first found, and these, by continual addition, give A_1, A_2 ..... A_n; and in this case (6) serves to test the correctness of $A_n - A_0$, which should be the same by both processes.

If, instead of the *first*, we have the *second* differential coefficients of A, denoted by F_{-2}, F_{-1}, F_0 ..... F_n, for $t=-2$, $t=-1$, $t=0$ ..... $t=n$, these may be arranged as before, with their differences d^1, d^2, &c.: —

$$\begin{array}{lll} t=-2 & F_{-2} & \\ & \quad d^1_{-2} & \\ =-1 & F_{-1} \quad d^2_{-2} & \\ & \quad d^1_{-1} \quad d^3_{-2} & \\ =\ 0 & F_0 \quad d^2_{-1} \quad d^4_{-2} & (7) \\ & \quad d^1_0 \quad d^3_{-1} & \\ =\ 1 & F_1 \quad d^2_0 & \\ & \quad d^1_1 & \\ =\ 2 & F_2 & \end{array}$$

By a process similar to that used in finding Δ^1_n, we obtain

$$\Delta^2_n = F_{n+1} + \tfrac{1}{12} d^2_n - \tfrac{1}{240} d^4_{n-1} + \tfrac{31}{60480} d^6_{n-2} -, \text{ &c.} \quad (8)$$

$$\Delta^1_n - \Delta^1_0 = \text{sum of all the quantities } F_1 ..... F_n + \tfrac{1}{12}(d^1_n - d^1_0) - \tfrac{1}{240}(d^3_{n-1} - d^3_{-1}) + \tfrac{31}{60480}(d^5_{n-2} - d^5_{-2}) -, \text{ &c.;} \quad (9)$$

and $A_n - A_0 =$ sum of all the quantities Δ^1_0 ..... Δ^1_{n-1}.

When, therefore, A_0 and Δ^1_0 are known, with the values of F for each interval, we obtain by (8) Δ^2_0, Δ^2_1 ..... Δ^2_{n-2}, thence by successive additions Δ^1_0, Δ^1_1 ..... Δ^1_{n-1}, and finally A_0, A_1 ..... A_n.

From the values of F_0, F_1 ..... F_{n-1}, the first differential coefficients of A may also be found by using (5), and considering F as the first differential coefficient of V; $V_{-\frac{1}{2}}$ being first known, by (5) we find $V_{+\frac{1}{2}}$, $V_{+\frac{3}{2}}$ ..... $V_{+n-\frac{1}{2}}$.

It will be observed, that when $V_{\frac{1}{2}}$ ..... $V_{n-\frac{1}{2}}$ are given, and it is required to find A_n for any time, we must first know A_0, and then we have $A_n = (A_n - A_0) + A_0$, $(A_n - A_0)$ being derived from (6). But when F_1 ..... F_{n-1} are known, and it is required to find A_n, we must know Δ^1_0 as well as A_0.

The following expressions derived from (3) and (4) give Δ^1_0 in terms of F and its differences, when V_0 or $V_{\frac{1}{2}}$ are known: —

$$\Delta^1_0 = V_0 + \tfrac{1}{2} F_0 + \tfrac{1}{6} d^1_0 - \tfrac{1}{24} d^2_0 + \tfrac{1}{45} d^3_0 - \tfrac{7}{480} d^4_0 + \tfrac{107}{60480} d^5_0 - \tfrac{1999}{241192} d^6_0 +, \text{ &c.;} \quad (10)$$

$$\Delta^1_0 = V_{\frac{1}{2}} + \tfrac{1}{24} d^1_0 - \tfrac{7}{5760} d^3_{-1} + \tfrac{4325}{3225600} d^5_{-2} -, \text{ &c.;} \quad (11)$$

which will be afterwards referred to.

(5) and (8) are two of the elementary formulæ in the method of mechanical quadratures. Usually the convergence of the differences of V and F, and the smallness of their coefficients, allow of the differences above the second or third order being neglected.

It is an objection which applies with some force to the practical use of this method, that a numerical error committed in any part of the work is, by the nature of the process, disseminated over a great mass of computations. The best safeguard for accuracy is the use of suitable tests and checks at proper intervals. The chief expenditure of labor will generally be in computing the series of numerical values of V and F; any considerable accidental errors in these quantities will show themselves in taking the differences. As these quantities are independently calculated, there is no tendency here to an aggregation of errors. But in the summation of V or F, an error of addition in forming any one value of A affects also those succeeding it. A security against this will be to use (6) and (9) after A_n has been independently found by the successive addition of $\Delta^1_0 \ldots\ldots \Delta^1_{n-1}$.

It is useful to know what degree of accuracy in V or F will be sufficient, in a given case, to compute A_n accurately to a certain number of decimal places. If V be known to the same number of decimal places (not significant figures) with A, and in every instance has an error e in its last decimal place, and always with the same sign, then the possible error of $A_n = n\,e$. And a similar error e' in F gives the possible error of $A_n = \frac{n\,(n-1)}{1.2}\,e'$.

But it is plain that these possible errors are highly improbable. Regarding it as equally probable that the last figure of each value of V or F is too large or too small by one unit, or exactly right, when the number of intervals or n is given, the comparative probabilities of the errors of A_n, or of $\Delta^1_n - \Delta^1_0$, being within certain limits, will be nearly expressed by

$$\frac{1^2 \,.\, 2^2 \,.\, 3^2 \,.\,\ldots\,.\, h^2}{1\,.\,2\,.\,3\,.\,\ldots\,.\,a\,.\,1\,.\,2\,.\,3\,.\,\ldots\,.\,b}\,;$$

where a and b are respectively the number of times that the last decimal place of V or of F must be too large and too small by unity, in order to produce the given errors in A_n or $\Delta^1_n - \Delta^1_0$; the whole number of instances in which V or F will be too large or too small being assumed as about two thirds of n, or $a + b = \frac{2}{3}\,n$, and $h = \frac{1}{3}\,n = \frac{a+b}{2}$, a, b, and h being the nearest whole numbers to their exact values, and unity the probability that $a = b$, or that the error of $A_n = 0$, which is its most probable value.

When $A_n - A_0$, or $\Delta^1_n - \Delta^1_0$, increases pretty uniformly, V will be of the same order with $\frac{1}{n}\,(A_n - A_0)$ and F of the same order with $\frac{1}{n}\,(\Delta^1_n - \Delta^1_0)$, and consequently the number of significant figures in V or F will usually be much less than in A. But these

conditions are not susceptible of any precise statement, being affected by a variety of circumstances.

We now proceed to the application of the method of quadratures to some examples in astronomy.

II. *Computation of the Radius Vector r in Orbits of any Eccentricity.*

The differential expression which seems best fitted for this purpose is

$$Fr^2 = \frac{2\mu}{r} - \frac{2\mu}{a}. \tag{12}$$

Fr^2 being the second differential coefficient of r^2, and $\frac{1}{a}$ the reciprocal of the semi-axis of the orbit, which is $= 0$ in the parabola, and negative in the hyperbola; μ is the sun's mass + the mass of the planet, which, when τ is the number of mean solar days in each interval, and the mass of the body is neglected, may be expressed by $\mu = k^2\tau^2$, log. $k = 8.2355814$.

We shall suppose that r_0^2 and $\Delta^1 r_0^2 = r_1^2 - r_0^2$ are given, with the semi-axis of the orbit, and that it is required to compute a series of values of r from $t=0$ to $t = n\tau$; τ being taken such that $\frac{2\mu}{r}$ is very small.

The first step is to compute F_0 and F_1 from (12) using a, r_0, and r_1. As $\frac{2\mu}{a}$ is a constant, each value of F requires only the calculation of $\frac{2\mu}{r}$ to be repeated for each interval. Neglecting, at first, $\frac{1}{12} d_0^2$ in (8), which is of the order of the fourth differences of r^2, F_1 added to Δ_0^1 gives Δ_1^1, and thence r_2^2, very nearly; this value of r_2^2 used in (12) gives a very exact value of F_2, because whatever error there may be in r_2, it is multiplied in F_2, by the coefficient μ, which we may make as small as we please by diminishing τ.

Arranging now F_0, F_1, and F_2 in a vertical column, and taking the differences,

$t=0$	F_0			r_0^2	
		d_0^1			Δ_0^1
$t=1$	F_1		d_0^2	r_1^2	
		d_1^1			Δ_1^1
$t=2$	F_2			r_2^2	

we obtain d_0^2, with which we correct the first value of r_2^2. This correction, where the intervals between r_0^2, r_1^2, &c., do not exceed two or three days, or as many degrees of heliocentric motion, will be exceedingly small, and wholly insensible on F_2, which may next be used to find $r_3^2 = r_2^2 + \Delta_1^1 + F_2$; it being seldom necessary to notice the differences of F above the second.

After F is known for two or three intervals, r^2 follows for the remaining intervals without intervening approximation. In this manner r^2 may be computed with accuracy in the seventh place of decimals, with logarithmic tables of five places, each value re-

quiring but one new logarithm. Table I., at the end of this article, contains numerical values of $\frac{2\mu}{r}$, with r^2 for the argument, supposing the interval to be one day.

It is evident that this method cannot be advantageously employed, unless the intermediate values of r between r_0 and r_n are wanted.

In the following example, r is the radius vector of Halley's Comet for each Greenwich mean midnight, from August 1st to August 20th, 1835; using the elements given in the *Nautical Almanac* for 1839. The influence of the second and higher differences of F is insensible, so that $\Delta^2_n = F_{n+1}$, and the whole series is calculated directly from Table I., without using logarithms after computing the constants r_0^2, $\Delta^1 r_0^{21}$, and $\frac{2\mu}{a}$.

$r_0^2 = 4.019789\ 0$; $\quad \Delta^1 r_0^2 = -0.055698\ 0$; $\quad -\frac{2\mu}{a} = -0.000032\ 7$.

$\frac{2\mu}{r}$ is taken from Table I., with the argument r_n^2, the value of r^2, next to r_n^2, being $r_{n+1}^2 = r_n^2 + \Delta^1_{n-1} + F_n$. The correctness of the series may be tested by computing r_n^2 for August 20.5 by the usual methods.

	r^2	$\Delta^1 r^2$	$\Delta^2 r^2$	$-\frac{2\mu}{a}$	$\frac{2\mu}{r}$
1835, August 1.5	4.019789 0				
		−55698 0			
2.5	3.964091 0		+264 5 =	−32 7	+297 2
		55433 5	266 6 =	"	+299 3
3.5	3.908657 5				
		55166 9	268 8 =	"	+301 5
4.5	3.853490 6				
		54898 1	270 8 =	"	+303 5
5.5	3.798592 5				
		54627 3	273 2 =	"	+305 9
6.5	3.743965 2				
		54354 1	275 3 =	"	+308 0
7.5	3.689611 1				
		54078 8	277 7 =	"	+310 4
8.5	3.635532 3				
		53801 1	280 0 =	"	+312 7
9.5	3.581731 2				
		53521 1	282 2 =	"	+314 9
10.5	3.528210 1				
		53238 9	284 8 =	"	+317 5
11.5	3.474971 2				
		52954 1	287 1 =	"	+319 8
12.5	3.422017 1				
		52667 0	289 7 =	"	+322 4
13.5	3.369350 1				
		52377 3	292 3 =	"	+325 0
14.5	3.316972 8				
		52085 0	294 8 =	"	+327 5
15.5	3.264887 8				
		51790 2	297 5 =	"	+330 2
16.5	3.213097 6				
		51492 7	300 1 =	"	+332 8
17.5	3.161604 9				
		51192 6	302 8 =	"	+335 5
18.5	3.110412 3				
		50889 8			
19.5	3.059522 5	−50584 2	+305 6 =	"	+338 3
20.5	3.008938 3				

(13) The substitution of $Vr^2 = \frac{dr}{dt} = \frac{2e\sqrt{\mu}}{\sqrt{p}} r \sin. v = 2e\sqrt{\mu a} \sin. u$

in equations (10) or (11) affords an accurate value of $\Delta^1 r_0^2$ when Fr_0^2 and its differences are known. Or it may be obtained from the expressions,

(14) $$r_1 - r_0 = \frac{2e}{p} r_1 r_0 \sin. \tfrac{1}{2}(v_1 + v_0) \sin. \tfrac{1}{2}(v_1 - v_0) = 2ae \sin. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0),$$

$$\Delta^1 r_0^2 = (r_1 + r_0)(r_1 - r_0),$$

e and p being the eccentricity and semi-parameter of the orbit, and u and v the eccentric and true anomalies.

III. *Computation of Heliocentric Coördinates x, y, and z, by Quadratures.*

The method of proceeding so nearly resembles that for finding r, that a few words will serve to introduce it.

According as x, y, or z is to be found, we have

$$Fx = -\tfrac{\mu}{r^3}x,\quad Fy = -\tfrac{\mu}{r^3}y,\quad Fz = -\tfrac{\mu}{r^3}z. \tag{15}$$

With the constants x_0, y_0, z_0, $\Delta^1 x_0$, $\Delta^1 y_0$, and $\Delta^1 z_0$, and the series for r^2 as already computed, we obtain F_0 and F_1, and thence x_2, y_2, and z_2; Fx_2, Fy_2, and Fz_2 give x_3, y_3, and z_3, and these again x_4, y_4, and z_4, and so on; noticing the higher orders of differences when necessary.

A very useful test of the accuracy of the whole series for r, x, y, and z is afforded by putting

$$r_n^2 = x_n^2 + y_n^2 + z_n^2. \tag{16}$$

For if this condition is satisfied, it indicates that every preceding value of r, x, y, and z, from $t=0$ to $t=n\tau$, is correct.

In calculating x, y, and z to seven places of decimals, with logarithms of five figures, the number of days in each interval should not exceed $2r$. For the maximum value of F is $=-\frac{\mu}{r^2}=-k^2\left(\frac{\tau}{r}\right)^2$. Since $k^2=0.0003$ about, if $\frac{\tau}{r}>2$, F will not be given with accuracy beyond seven places of decimals with five-figure logarithms.

In the following example, x, y, and z are the coördinates of Halley's comet, referred to the equator, for Greenwich mean midnight, from August 1.5 to August 9.5, 1835. The necessary constants, determined from the elements in the *Nautical Almanac* for 1839, are as follows: —

August 1.5, $x_0 = +0.9934592$ $\quad \Delta_0^1 x = +0.0007486\ 5$

$y_0 = +1.6196067$ $\quad \Delta_0^1 y = -0.0163206\ 0$

$z_0 = +0.6400825$ $\quad \Delta_0^1 z = -0.0035933\ 7$

The corrections for second differences of F are insensible.

1835,	x	$\Delta^1 x$	$-\frac{\mu}{r^3}x$	y	$\Delta^1 y$	$-\frac{\mu}{r^3}y$	z	$\Delta^1 z$	$-\frac{\mu}{r^3}z$
Aug. 1.5	+0.9934592 0			+1.6196067 0			+0.6400825 0		
		+7486 5			−163206 0			−35933 7	
2.5	.9942078 5		−372 9	.6032861 0		−601 2	.6364891 3		−238 7
		7113 6			163807 2			36172 4	
3.5	.9949192 1		381 2	.5869053 8		607 8	.6328718 9		242 4
		6732 4			164415 0			36414 8	
4.5	.9955924 5		389 6	.5704638 8		614 5	.6292304 1		246 2
		6342 8			165029 5			36661 0	
5.5	.9962267 3		398 2	.5539609 3		621 1	.6255643 1		250 1
		5944 6			165650 6			36911 1	
6.5	.9968211 9		407 2	.5373958 7		628 1	.6218732 0		254 1
		5537 4			166278 7			37165 2	
7.5	.9973749 3		416 5	.5207680 0		635 1	.6181566 8		258 1
		5120 9			166913 8			37423 3	
8.5	.9978870 2		−426 1	.5040766 2		−642 2	.6144143 5		−262 3
		+4694 8			−167556 0			−37685 6	
9.5	+0.9983565 0			+1.4873210 2			+0.6106457 9		

When x, y, and z are wanted for a long period, it will be well to guard against an accumulation of errors in the series, by computing a new set of constants for another epoch, directly from the elements of the orbit.

As it is of importance that $\Delta^1 x_0$, $\Delta^1 y_0$, and $\Delta^1 z_0$ should be known beyond the last decimal place of x_0, y_0, and z_0, the following equations, or others of a similar nature, are useful in determining them.

The projections of the radius vector in an ellipse upon the principal axes are

$$r \sin. v = \sqrt{a p} \sin. u, \text{ and } r \cos. v = a (\cos. u - e).$$

And since these axes have a fixed direction, the coördinates of a body moving in an elliptical orbit, referred to any plane passing through the sun, are

$$(17)\quad x = A_0 + A_1 \sin. u + A_2 \sin.^2 \tfrac{1}{2} u,\ y = B_0 + B_1 \sin. u + B_2 \sin.^2 \tfrac{1}{2} u,\ z = C_0 + C_1 \sin. u + C_2 \sin.^2 \tfrac{1}{2} u;$$

whence

$$(18)\quad \begin{aligned} \Delta^1 x_0 &= x_1 - x_0 = 2 A_1 \cos. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0) + A_2 \sin. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0); \\ \Delta^1 y_0 &= y_1 - y_0 = 2 B_1 \cos. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0) + B_2 \sin. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0); \\ \Delta^1 z_0 &= z_1 - z_0 = 2 C_1 \cos. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0) + C_2 \sin. \tfrac{1}{2}(u_1 + u_0) \sin. \tfrac{1}{2}(u_1 - u_0); \end{aligned}$$

A_0, A_1, &c., being constant quantities, determined by giving particular values to u. Putting for u its values when $v = 0°$, and $v = 90°$, we find

$$(19)\quad \begin{aligned} A_0 &= X, & A_1 &= \frac{X'}{\sqrt{1-e^2}}, & A_2 &= -\frac{2X}{1-e}; \\ B_0 &= Y, & B_1 &= \frac{Y'}{\sqrt{1-e^2}}, & B_2 &= -\frac{2Y}{1-e}; \\ C_0 &= Z, & C_1 &= \frac{Z'}{\sqrt{1-e^2}}, & C_2 &= -\frac{2Z}{1-e}. \end{aligned}$$

X, Y, and Z are the coördinates of the perihelion point of the orbit; X', Y', and Z', those of the point of intersection of the parameter with the orbit, that is, a point 90° from the perihelion.

In the parabola the above expressions become

$$(20)\quad x = X + X' \tan. \tfrac{1}{2} v - X \tan.^2 \tfrac{1}{2} v, \qquad y = Y + Y' \tan. \tfrac{1}{2} v - Y \tan.^2 \tfrac{1}{2} v, \qquad z = Z + Z' \tan. \tfrac{1}{2} v - Z \tan.^2 \tfrac{1}{2} v.$$

$$(21)\quad \begin{aligned} \Delta^1 x_0 &= x_1 - x_0 = X' \frac{\sin. \frac{1}{2}(v_1 - v_0)}{\cos. \frac{1}{2} v_1 \cos. \frac{1}{2} v_0} - X \frac{\sin. \frac{1}{2}(v_1 - v_0) \sin. \frac{1}{2}(v_1 + v_0)}{\cos.^2 \frac{1}{2} v_1 \cos.^2 \frac{1}{2} v_0}; \\ \Delta^1 y_0 &= y_1 - y_0 = Y' \frac{\sin. \frac{1}{2}(v_1 - v_0)}{\cos. \frac{1}{2} v_1 \cos. \frac{1}{2} v_0} - Y \frac{\sin. \frac{1}{2}(v_1 - v_0) \sin. \frac{1}{2}(v_1 + v_0)}{\cos.^2 \frac{1}{2} v_1 \cos.^2 \frac{1}{2} v_0}; \\ \Delta^1 z_0 &= z_1 - z_0 = Z' \frac{\sin. \frac{1}{2}(v_1 - v_0)}{\cos. \frac{1}{2} v_1 \cos. \frac{1}{2} v_0} - Z \frac{\sin. \frac{1}{2}(v_1 - v_0) \sin. \frac{1}{2}(v_1 + v_0)}{\cos.^2 \frac{1}{2} v_1 \cos.^2 \frac{1}{2} v_0}. \end{aligned}$$

By differentiating the above equations, and substituting for $\frac{du}{dt}$ and $\frac{dv}{dt}$ the proper values, we find the following expressions for the differential coefficients of x, y, and z:

$$(22)\quad Vx = (A_1 \cos. u + \tfrac{1}{2} A_2 \sin. u) \frac{k}{r\sqrt{a}},\ Vy = (B_1 \cos. u + \tfrac{1}{2} B_2 \sin. u) \frac{k}{r\sqrt{a}},\ Vz = (C_1 \cos. u + \tfrac{1}{2} C_2 \sin. u) \frac{k}{r\sqrt{a}}.$$

And in the parabola,

$$(23)\quad Vx = (X' - 2X \tan. \tfrac{1}{2} v) \frac{k}{r\sqrt{p}},\quad Vy = (Y' - 2Y \tan. \tfrac{1}{2} v) \frac{k}{r\sqrt{p}},\quad Vz = (Z' - 2Z \tan. \tfrac{1}{2} v) \frac{k}{r\sqrt{p}}.$$

IV. *To find by Quadratures the Partial Differentials of the Geocentric Right Ascension and Declination of a Comet or Planet relatively to the Elements of its Orbit.*

This is a problem of frequent occurrence where it is required to find the orbit which best satisfies a large number of observations. Its nature is such that no solution can be expected, for the attainment of which a very considerable amount of labor is not necessary.

After the approximate elements of the orbit are known, instead of varying these elements themselves, as in the usual method of finding equations of condition for their correction, it will be an equivalent process to use x_0, y_0, z_0, Vx_0, Vy_0, and Vz_0 for the assumed constants of the orbit, and to form equations of condition for determining their corrections. The best epoch for x_0, y, &c., will usually be at nearly midway between the extreme observations. The coefficients of the unknown quantities in these equations are the partial differentials of α and θ, the geocentric right ascension and declination, relatively to x_0, y_0, z_0, Vx_0, Vy_0, and Vz_0, and they must be known before the equations can be solved.

Having with the above constants found x, y, and z from $t=0$ to $t=n\tau$, by the process of Sect. III., each constant is to be separately increased by the addition of a quantity δx_0, δy_0, δz_0, δVx_0, δVy_0, and δVz_0, small enough to allow of its square being neglected. Commencing with δx_0, from the equations

$$r^2 = x^2 + y^2 + z^2, \quad \tfrac{1}{2} Vr^2 = xVx + yVy + zVz, \tag{24}$$

$$\tfrac{1}{2} Fr^2 = \tfrac{\mu}{r} - \tfrac{\mu}{a} = (Vx)^2 + (Vy)^2 + (Vz)^2 - \tfrac{\mu}{r}, \quad Fx = -\tfrac{\mu}{r^3} x, \quad Fy = -\tfrac{\mu}{r^3} y, \quad Fz = -\tfrac{\mu}{r^3} z, \tag{25}$$

we have

$$\delta r_0^2 = 2 x_0 \delta x_0, \quad V\delta r_0^2 = 2 Vx_0 \delta x_0, \quad F\delta r_0^2 = -2 Fx_0 \delta x_0 = -\delta\left(\tfrac{\mu}{a}\right), \tag{26}$$

in which Vx_0 and Fx_0 correspond to the intervals between δr_0^2 and δr_1^2 which may be considerably larger than when the total value of x is computed. As Vx, Vy, and Vz will vary from their previous values after the first interval, we have, excepting when $t=0$, $F\delta r^2 = -\tfrac{\mu}{r^3}\delta r^2 - \delta\left(\tfrac{2\mu}{a}\right)$; and since $2F\delta r_0^2 = -4Fx_0\delta x_0 = -\delta\left(\tfrac{2\mu}{a}\right)$ is a con- (27)
stant for all values of r, and $\tfrac{\mu}{r^3}$ is known, $F\delta r^2$ will be known when δr^2 is known. And the process of finding δr^2 from $t=0$ to $t=n\tau$ is very much the same as that employed in Sect. II. Neglecting at first in (10) δd_0^1 and higher orders of the differences of $F\delta r^2$, which will be very small, we obtain δr_1^2 nearly, which affords an accurate value of $F\delta r_1^2 = -\tfrac{\mu}{r_1^3}\delta r_1^2 - \delta\tfrac{2\mu}{a}$. Again, neglecting δd_0^2, we find Fdr_2^2, and so on, correcting for the differences of $F\delta r^2$ as far as may be necessary to give sufficiently accurate values of $\delta r_0^2 \ldots\ldots \delta r_n^2$. For the corresponding equations for the changes of y and z, they are to be substituted for x in (26).

When Vx_0 is varied, we have from (24),

(28) $$\delta r_0^2 = 0, \qquad V\delta r_0^2 = 2x_0\delta Vx_0, \qquad F\delta r_0^2 = 4Vx_0\delta Vx_0 = -\delta\left(\tfrac{2\mu}{a}\right),$$

(29) and for any other epoch excepting $t=0$, $F\delta r^2 = -\frac{\mu}{r^3}\delta r^2 - \delta\left(\frac{2\mu}{a}\right)$; and since for all values of t, $4Vx_0\,\delta Vx_0 = -\delta\left(\frac{2\mu}{a}\right)$ is constant as before, and $\frac{\mu}{r^3}$ is already known, δr^2 will follow from equations (27) and (28), when Vx_0 is varied, precisely as from equations (26) and (27) when x_0 is varied.

Having thus found δr^2 from $t=0$ to $t=n\tau$, it remains to determine δx, δy, and δz for the same period.

From (25) we find

(30) $$F\delta x = Fx\left(\frac{\delta x}{x} - \tfrac{3}{2}\frac{\delta r^2}{r^2}\right), \qquad F\delta y = Fy\left(\frac{\delta y}{y} - \tfrac{3}{2}\frac{\delta r^2}{r^2}\right), \qquad F\delta z = Fz\left(\frac{\delta z}{z} - \tfrac{3}{2}\frac{\delta r^2}{r^2}\right),$$

in which all the quantities are known excepting δx, δy, and δz. When x_0 is varied, we have

(31) $$\delta x_0 = \delta x_0, \qquad V\delta x_0 = 0, \qquad F\delta x_0 = Fx_0\left(\frac{\delta x_0}{x_0} - \tfrac{3}{2}\frac{\delta r_0^2}{r_0^2}\right).$$

We may, therefore, find approximate values of δx_1 and δx_2, which give accurate values of $F\delta x_1$ and $F\delta x_2$, which may be used to find δx_2, and so on, correcting for the differences of $F\delta x$ as far as is necessary, and we thus obtain δx from $t=0$ to $t=n\tau$.

Again, when x_0 is varied,

(32) $$\begin{aligned} &\delta y_0 = 0, && V\delta y_0 = 0, && F\delta y_0 = -Fy_0\tfrac{3}{2}\frac{\delta r_0^2}{r_0^2}; \\ &\delta z_0 = 0, && V\delta z_0 = 0, && F\delta z_0 = -Fz_0\tfrac{3}{2}\frac{\delta r_0^2}{r_0^2}; \end{aligned}$$

from which we proceed to find δy_1, δz_1, &c., which will be small compared with δx for several intervals.

When Vx_0 is varied, we have, for $t=0$,

(33) $$\begin{aligned} &\delta x_0 = 0, && V\delta x_0 = \delta Vx_0, && F\delta x_0 = 0; \\ &\delta y_0 = 0, && V\delta y_0 = 0, && F\delta y_0 = 0; \\ &\delta z_0 = 0, && V\delta z_0 = 0, && F\delta z_0 = 0; \end{aligned}$$

and at any other epoch the equations (30), by which δx, δy, and δz may be found from $t=0$ to $t=n\tau$.

When y_0 and Vy_0, z_0 and Vz_0, are varied, the operations are precisely analogous to those employed for δx_0 and δVx_0.

Finally, the correctness of each series is tested by putting at $t=n\tau$

(34) $$\tfrac{1}{2}\delta r^2 = x\delta x + y\delta y + z\delta z.$$

The changes of α and θ, the geocentric right ascension and declination, are, $\mathbf{x}$ and $\mathbf{z}$ being the geocentric coördinates,

(35) $$\begin{aligned} \text{sin. } \delta\alpha &= \frac{\text{cos. } \alpha}{\mathbf{x}}(\delta y \text{ cos. } \alpha - \delta x \text{ sin. } \alpha); \\ \text{sin. } \delta\theta &= \frac{\text{sin.}^2\theta}{\mathbf{z}}(\delta z \text{ cot. } \theta - \delta y \text{ sin. } \alpha - \delta x \text{ cos. } \alpha). \end{aligned}$$

The equations of condition are then to be formed and solved as usual.

V. *Calculation of Perturbations by Quadratures.*

The usual application of quadratures to the calculation of perturbations is in the summation of the momentary variations of the elements of the disturbed orbit, which, it has been found, may be expressed with much simplicity, considering the general intricacy of the problem, in terms of the coördinates x, y, and z, and their first differential coefficients, combined with the disturbing forces. For this purpose the positions of all the disturbing bodies of the system are computed for the middle of each interval, and also, either directly, or indirectly by the use of auxiliary angles, the coördinates of the disturbed body x, y, and z, with their first differential coefficients for the same epochs. From these, combined with the disturbing forces from $t=\frac{1}{2}$ to $t=n-\frac{1}{2}$, are derived the momentary variations of each element for the same times, and thence, by using (5) to sum up their values, will result the alteration of each of the six elements at the end of each interval.

After the perturbations of the elements for each interval have been ascertained, the changes which they introduce into x, y, and z are investigated, leading finally to the perturbations in geocentric right ascension and declination. Where the change of the elements is large, the process is sometimes repeated with corrected values of x, y, and z, in order to include the squares of the disturbing forces.

If we commence with the constants x_0, y_0, z_0, Vx_0, Vy_0, and Vz_0 for $t=0$, we have

$$Fx=-\tfrac{\mu}{r^3}x-\mu A, \qquad Fy=-\tfrac{\mu}{r^3}y-\mu B, \qquad Fz=-\tfrac{\mu}{r^3}-\mu C; \tag{36}$$

in which

$$\begin{aligned}
\mu A &= m'\left(\tfrac{x-x'}{\varrho'^3}+\tfrac{x'}{r'^3}\right)+m''\left(\tfrac{x-x''}{\varrho''^3}+\tfrac{x''}{r''^3}\right)+\&c.,\\
\mu B &= m'\left(\tfrac{y-y'}{\varrho'^3}+\tfrac{y'}{r'^3}\right)+m''\left(\tfrac{y-y''}{\varrho''^3}+\tfrac{y''}{r''^3}\right)+\&c.,\\
\mu C &= m'\left(\tfrac{z-z'}{\varrho'^3}+\tfrac{z'}{r'^3}\right)+m''\left(\tfrac{z-z''}{\varrho''^3}+\tfrac{z''}{r''^3}\right)+\&c.,
\end{aligned} \tag{37}$$

are denominated the disturbing forces, μ being the sum of the masses of the sun and the disturbed body; m', m'', &c., the masses of the disturbing bodies; x', x'', &c., their coördinates from the sun; r', ϱ', r'', ϱ'', &c., their distances from the sun and from the disturbed body, of which the heliocentric coördinates and distance are x, y, z, and r. m', m'', &c., it will be noticed, being referred to the same unit with μ, are always very small compared with it, and therefore the second terms in (36) are much less than the first.

Making always $r^2=x^2+y^2+z^2$, instead of finding it by Sect. II., because the process there given cannot here be adopted, the semi-axis being no longer constant, we may compute Fx_0, Fx_1, &c., and thence find $\Delta^1 x_0$, $\Delta^1 y_0$, $\Delta^1 z_0$, x_1, x_2, &c., as in Sect. III., with this difference, that Fx, Fy, and Fz contain the terms μA, μB, and μC, and that r^2 is to be found from (38). (38)

Regarding Fx, Fy, and Fz as the first differential coefficients of Vx, Vy, and Vz, we obtain from the series $Fx_0 \ldots\ldots Fx_n$, $Fy_0 \ldots\ldots Fy_n$, $Fz_0 \ldots\ldots Fz_n$, by using (5), Vx, Vy, and Vz for $t = (n - \frac{1}{2})\tau$. As we know x, y, and z for the same epoch, we can compute the elements of the orbit at $t = (n - \frac{1}{2})\tau$, and the differences between them and those at $t = 0$ are their perturbations from $t = 0$ to $t = (n - \frac{1}{2})\tau$. When $n\tau$ is very large, which will depend on the heliocentric motion of the disturbed body, it will not be safe to use logarithms of five figures to find Fx, Fy, and Fz, and the labor of computing them is thereby much increased.

In order to avoid this difficulty, if we denote by δ_n the whole perturbation of the quantity to which it is affixed up to the moment $t = n\tau$, so that δx_n is the difference between the actual value of x_n and that which it would have had if from the time $t = 0$ the sun's force alone had been exerted upon it, we may suppose the whole period to be divided into portions such that from $t = 0$ to $t' = 0$, from $t' = 0$ to $t'' = 0$, &c., the squares of δx, δy, and δz, and their products with m', m'', &c., are insensible; we then have from (36)

$$(39)\quad F\delta x = Fx\left(\frac{\delta x}{x} - \tfrac{3}{2}\frac{\delta r^2}{r^2}\right) - \mu A, \qquad F\delta y = Fy\left(\frac{\delta y}{y} - \tfrac{3}{2}\frac{\delta r^2}{r^2}\right) - \mu B, \qquad F\delta z = Fz\left(\frac{\delta z}{z} - \tfrac{3}{2}\frac{\delta r^2}{r^2}\right) - \mu C,$$

by which δx, δy, and δz may be determined from $t = 0$ to $t' = 0$, independently of the exact values of x, y, and z. For although the unknown quantities δx, δy, and δz enter the expressions (39), the coefficient $\frac{\mu}{r^3}$ may be made as small as we please, it being of the order of the square of the heliocentric motion of the disturbed body in one interval. So that, by taking τ sufficiently small, we make the first terms of $F\delta x$, $F\delta y$, and $F\delta z$ very small compared with μA, μB, and μC, and this will be the case for several of the first intervals.

$$(40)\quad \text{At } t = 0, \quad \begin{array}{lll} \delta x_0 = 0, & V\delta x_0 = 0, & F\delta x_0 = -\mu A_0, \\ \delta y_0 = 0, & V\delta y_0 = 0, & F\delta y_0 = -\mu B_0, \\ \delta z_0 = 0, & V\delta z_0 = 0, & F\delta z_0 = -\mu C_0, \end{array}$$

(10) gives $\Delta^1 \delta x_0 = -\frac{1}{2}\mu A_0$, neglecting d_0^1, and thence

$$\delta x_1 = -\tfrac{1}{2}\mu A_0, \qquad \delta y_1 = -\tfrac{1}{2}\mu B_0, \qquad \delta z_1 = -\tfrac{1}{2}\mu C_0.$$

With these we obtain $F\delta x_1$, $F\delta y_1$, and $F\delta z_1$, noticing that $\frac{1}{2}\delta r^2 = x\delta x + y\delta y + z\delta z$. After correcting δx_1, δy_1, and δz_1 as far as necessary for the differences of $F\delta x$, $F\delta y$, and $F\delta z$, the computation of the rest of the series will be direct, and conducted on the same principles as have already been detailed in the preceding sections. From δx, δy, and δz, we pass to the perturbations in geocentric right ascension and declination by means of (35).

$F\delta x$, $F\delta y$, and $F\delta z$ being the first differential coefficients of δVx, δVy, and δVz,

the summation of $F\delta x_0 \ldots\ldots F\delta x_n$, $F\delta y_0 \ldots\ldots F\delta y_n$, $F\delta z_0 \ldots\ldots F\delta z_n$ by (5) will give δVx, δVy, and δVz at the epoch $t=(n-\frac{1}{2})\tau$; for this time we also know δx, δy, and δz, and these give, added to Vx, Vy, Vz, x, y, and z computed from the elements at $t=0$, the actual values of Vx, Vy, Vz, x, y, and z for the epoch $t=(n-\frac{1}{2})\tau$ or $t'=0$; we may then proceed to find δx, δy, and δz from $t'=0$ to $t''=0$ precisely as between $t=0$ and $t'=0$.

There seems to be no ready mode of testing δx, δy, and δz without computing δr^2 independently; we might then put $\frac{1}{2}\delta r^2 = x\delta x + y\delta y + z\delta z$. But the expression for (41)
$F\delta r^2$ under disturbing forces is rather complicated. It may be well to notice, however, that in an undisturbed orbit the quantity $q=xVy-yVx$ is constant. Under the influence of disturbing forces it is shown in most treatises on perturbations that the momentary variation of q is

$$Vq = y\mu A - x\mu B \tag{42}$$

at $t=0$, $\delta q=0$; then using (5) we may sum up the known values of Vq from $t=\frac{1}{2}\tau$ to $t=(n-\frac{1}{2})\tau$, whence we find δq at $t=(n-\frac{1}{2})\tau$, and we ought to have

$$q+\delta q = xVy - yVx, \tag{43}$$

x, y, Vx, and Vy being the actual values of x, y, &c., found as above at $t=(n-\frac{1}{2})\tau$.

Assuming for the elements of the moon's orbit at Greenwich, midnight, June 15th, 1846,

Longitude of Descending Node,	36° 04′ 47″.0	True Eq., June 15, 1846.
Perigee to the Descending Node,	107° 35′ 07″.6	True Eq., June 15, 1846.
Inclination,	5° 08′ 35″.4	
Mean Longitude,	57° 45′ 40″.7	
Mean Daily Motion,	13° 24′ 30″.66	
Log. Eccentricity,	8.6487211	
Mean Distance $=\frac{1}{400}$ of the sun's,		

δx, δy, and δz may be found for a few days by the method explained above. The exact values of $F\delta x$, $F\delta y$, and $F\delta z$ are

$$F\delta x = M\left(\frac{x-\delta x}{(r-\delta r)^3}-\frac{x}{r^3}\right)-MA;\quad F\delta y = M\left(\frac{y-\delta y}{(r-\delta r)^3}-\frac{y}{r^3}\right)-MB;\quad F\delta z = M\left(\frac{z-\delta z}{(r-\delta r)^3}-\frac{z}{r^3}\right)-MC;$$

$$(2r-\delta r)\,\delta r = (2x-\delta x)\,\delta x + (2y-\delta y)\,\delta y + (2z-\delta z)\,\delta z;$$

M being the sum of the masses of the earth and moon, and MA, MB, and MC the sun's disturbing forces, those of the planets being neglected. Taking the ecliptic for the plane of x and y at $t=0=$ June 15.5, we have

$$\delta x_0 = 0,\quad \delta y_0 = 0,\quad \delta z_0 = 0;\quad V\delta x_0 = 0,\quad V\delta y_0 = 0,\quad V\delta z_0 = 0;$$
$$F\delta x_0 = -MA,\quad F\delta y_0 = -MB,\quad F\delta z_0 = -MC;$$

and thence δx, δy, and δz in parts of the moon's mean distance for intervals of twelve hours, as follows: —

1846,	$F\delta x$	δx	$F\delta y$	δy	$F\delta z$	δz
June 15.5	—.0000684 9	—.0000000 0	—.0000021 5	+.0000000 0	—.0000043 5	—.0000000 0
" 16.0	685 2	00341 9	+.0000127 5	14 1	38 7	20 9
" 16.5	697 8	01370 0	267 5	154 9	33 9	80 5
" 17.0	715 6	03096 4	386 3	561 4	28 1	173 9
" 17.5	725 8	05537 8	477 0	1351 8	20 6	295 2
" 18.0	713 4	08703 1	539 6	2616 9	—.0000011 1	436 9
" 18.5	663 5	12578 7	582 2	2419 9	+.0000000 3	589 5
" 19.0	566 8	17113 9	619 0	6804 6	13 1	741 6
" 19.5	—.0000118 5	—.0022211 7	+.0000670 6	+.0009808 4	+.0000025 6	—.0000880 5

Which correspond to the following values of the perturbations in longitude and latitude.

	$\delta\alpha$	$\delta\varsigma$
1846, June 15.5	+0′ 00.″00	—0.″00
16.0	0 00.01	0.04
16.5	0 05.43	0.35
17.0	0 24.52	1.36
17.5	1 03.11	3.37
18.0	2 05.63	7.17
18.5	3 34.07	10.95
19.0	5 27.69	15.80
19.5	+7 42.71	—20.70

For longer intervals, the terms producing the principal inequalities might be excluded from $F\delta x$, $F\delta y$, and $F\delta z$.

Table I. contains numerical values of $\frac{2\mu}{r}$ with the argument r^2. The interval adopted for the value of μ is one mean solar day. The use of the table is explained on pp. 193, 194.

Table II. contains logarithmic values of $\frac{\mu}{r^3}$, with the argument r^2, and is useful in calculating heliocentric coördinates.

TABLE I.

r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.
	0.000			0.000			0.000			0.000			0.000			0.000	
0.351	9989 4		0.424	9088 8		0.497	8394 9		0.570	7839 0		0.643	7380 5		0.716	6994 1	
.352	9975 2	14 2	.425	9078 1	10 7	.498	8386 5	8 4	.571	7832 1	6 9	.644	7374 8	5 7	.717	6989 2	4 9
.353	9961 1	14 1	.426	9067 5	10 6	.499	8378 1	8 4	.572	7825 3	6 8	.645	7369 1	5 7	.718	6984 3	4 9
.354	9947 0	14 1	.427	9056 9	10 6	.500	8369 7	8 4	.573	7818 5	6 8	.646	7363 4	5 7	.719	6979 4	4 9
.355	9933 0	14 0	.428	9046 3	10 6	.501	8361 3	8 4	.574	7811 6	6 9	.647	7357 7	5 7	.720	6974 6	4 8
.356	9919 0	14 0	.429	9035 7	10 6	.502	8353 0	8 3	.575	7804 8	6 8	.648	7352 0	5 7	.721	6969 8	4 8
.357	9905 1	13 9	.430	9025 2	10 5	.503	8344 7	8 3	.576	7798 1	6 7	.649	7346 3	5 7	.722	6964 9	4 9
.358	9891 2	13 9	.431	9014 7	10 5	.504	8336 5	8 2	.577	7791 3	6 8	.650	7340 7	5 6	.723	6960 1	4 8
.359	9877 4	13 8	.432	9004 3	10 4	.505	8328 2	8 3	.578	7784 6	6 7	.651	7335 1	5 6	.724	6955 3	4 8
.360	9863 7	13 7	.433	8994 1	10 2	.506	8320 0	8 2	.579	7777 8	6 8	.652	7329 4	5 7	.725	6950 5	4 8
.361	9850 0	13 7	.434	8983 7	10 4	.507	8311 8	8 2	.580	7771 1	6 7	.653	7323 8	5 6	.726	6945 7	4 8
.362	9836 4	13 6	.435	8973 4	10 3	.508	8303 6	8 2	.581	7764 5	6 6	.654	7318 2	5 6	.727	6940 9	4 8
.363	9822 8	13 6	.436	8963 1	10 3	.509	8295 5	8 1	.582	7757 8	6 7	.655	7312 6	5 6	.728	6936 2	4 7
.364	9809 3	13 5	.437	8952 9	10 2	.510	8287 3	8 2	.583	7751 2	6 6	.656	7307 1	5 5	.729	6931 4	4 8
.365	9795 9	13 4	.438	8942 6	10 3	.511	8279 2	8 1	.584	7744 5	6 7	.657	7301 5	5 6	.730	6926 7	4 7
.366	9782 5	13 4	.439	8932 3	10 3	.512	8271 1	8 1	.585	7737 9	6 6	.658	7295 9	5 6	.731	6921 9	4 8
.367	9769 1	13 4	.440	8922 1	10 2	.513	8263 1	8 0	.586	7731 3	6 6	.659	7290 4	5 5	.732	6917 2	4 7
.368	9755 8	13 3	.441	8912 0	10 1	.514	8255 1	8 0	.587	7724 7	6 6	.660	7284 9	5 5	.733	6912 5	4 7
.369	9742 6	13 2	.442	8901 9	10 1	.515	8247 1	8 0	.588	7718 1	6 6	.661	7279 4	5 5	.734	6907 8	4 7
.370	9729 5	13 1	.443	8891 8	10 1	.516	8239 1	8 0	.589	7711 6	6 5	.662	7273 9	5 5	.735	6903 1	4 7
.371	9716 3	13 2	.444	8881 8	10 0	.517	8231 0	8 1	.590	7705 0	6 6	.663	7268 4	5 5	.736	6898 4	4 7
.372	9703 3	13 0	.445	8871 8	10 0	.518	8223 0	8 0	.591	7698 5	6 5	.664	7262 9	5 5	.737	6893 7	4 7
.373	9690 2	13 1	.446	8861 8	10 0	.519	8215 1	7 9	.592	7692 0	6 5	.665	7257 4	5 5	.738	6889 1	4 6
.374	9677 3	12 9	.447	8851 8	10 0	.520	8207 2	7 9	.593	7685 5	6 5	.666	7252 0	5 4	.739	6884 4	4 7
.375	9664 4	12 9	.448	8841 9	9 9	.521	8199 3	7 9	.594	7679 0	6 5	.667	7246 6	5 4	.740	6879 8	4 6
.376	9651 5	12 9	.449	8832 1	9 8	.522	8191 5	7 8	.595	7672 6	6 4	.668	7241 2	5 4	.741	6875 2	4 6
.377	9638 7	12 8	.450	8822 3	9 8	.523	8183 6	7 9	.596	7666 1	6 5	.669	7235 8	5 4	.742	6870 6	4 6
.378	9625 9	12 8	.451	8812 5	9 8	.524	8175 8	7 8	.597	7659 7	6 4	.670	7230 4	5 4	.743	6865 9	4 7
.379	9613 2	12 7	.452	8802 7	9 8	.525	8168 0	7 8	.598	7653 3	6 4	.671	7225 0	5 4	.744	6861 3	4 6
.380	9600 6	12 6	.453	8793 0	9 7	.526	8160 2	7 8	.599	7646 9	6 4	.672	7219 6	5 4	.745	6856 7	4 6
.381	9587 9	12 7	.454	8783 3	9 7	.527	8152 5	7 7	.600	7640 5	6 4	.673	7214 3	5 3	.746	6852 2	4 5
.382	9575 4	12 5	.455	8773 6	9 7	.528	8144 8	7 7	.601	7634 1	6 4	.674	7208 9	5 4	.747	6847 6	4 6
.383	9562 9	12 5	.456	8764 0	9 6	.529	8137 0	7 8	.602	7627 8	6 3	.675	7203 6	5 3	.748	6843 0	4 6
.384	9550 4	12 5	.457	8754 4	9 6	.530	8129 3	7 7	.603	7621 5	6 3	.676	7198 2	5 4	.749	6838 5	4 5
.385	9538 0	12 4	.458	8744 8	9 6	.531	8121 6	7 7	.604	7615 2	6 3	.677	7192 9	5 3	.750	6833 9	4 6
.386	9525 6	12 4	.459	8735 3	9 5	.532	8114 0	7 6	.605	7608 9	6 3	.678	7187 6	5 3	.751	6829 4	4 5
.387	9513 3	12 3	.460	8725 8	9 5	.533	8106 4	7 6	.606	7602 6	6 3	.679	7182 3	5 3	.752	6824 8	4 6
.388	9501 1	12 2	.461	8716 3	9 5	.534	8098 8	7 6	.607	7596 3	6 3	.680	7177 0	5 3	.753	6820 3	4 5
.389	9488 8	12 3	.462	8706 9	9 4	.535	8091 2	7 6	.608	7590 1	6 2	.681	7171 7	5 3	.754	6815 8	4 5
.390	9476 7	12 1	.463	8697 5	9 4	.536	8083 6	7 6	.609	7583 8	6 3	.682	7166 5	5 2	.755	6811 3	4 5
.391	9464 5	12 2	.464	8688 1	9 4	.537	8076 0	7 6	.610	7577 6	6 2	.683	7161 2	5 3	.756	6806 8	4 5
.392	9452 4	12 1	.465	8678 8	9 3	.538	8068 5	7 5	.611	7571 4	6 2	684	7156 0	5 2	.757	6802 3	4 5
.393	9440 4	12 0	.466	8669 5	9 3	.539	8061 0	7 5	.612	7565 2	6 2	.685	7150 7	5 3	.758	6797 8	4 5
.394	9428 4	12 0	.467	8660 2	9 3	.540	8053 6	7 4	.613	7559 0	6 2	.686	7145 5	5 2	.759	6793 3	4 5
.395	9416 5	11 9	.468	8650 9	9 3	.541	8046 2	7 4	.614	7552 8	6 2	.687	7140 3	5 2	.760	6788 8	4 5
.396	9404 6	11 9	.469	8641 7	9 2	.542	8038 7	7 5	.615	7546 7	6 1	.688	7135 1	5 2	.761	6784 3	4 5
.397	9392 8	11 8	.470	8632 5	9 2	.543	8031 3	7 4	.616	7540 5	6 2	.689	7129 9	5 2	.762	6779 9	4 4
.398	9380 9	11 9	.471	8623 3	9 2	544	8024 0	7 3	.617	7534 4	6 1	.690	7124 8	5 1	.763	6775 4	4 5
.399	9369 2	11 7	.472	8614 2	9 1	.545	8016 6	7 4	.618	7528 3	6 1	.691	7119 6	5 2	.764	6771 0	4 4
.400	9357 5	11 7	.473	8605 1	9 1	.546	8009 3	7 3	.619	7522 2	6 1	.692	7114 5	5 1	.765	6766 6	4 4
.401	9345 8	11 7	.474	8596 0	9 1	.547	8001 9	7 4	.620	7516 1	6 1	.693	7109 4	5 1	.766	6762 1	4 5
.402	9334 2	11 6	.475	8587 0	9 0	.548	7994 6	7 3	.621	7510 0	6 1	.694	7104 2	5 2	.767	6757 7	4 4
.403	9322 6	11 6	.476	8577 9	9 1	.549	7987 4	7 2	.622	7504 0	6 0	.695	7099 1	5 1	.768	6753 3	4 4
.404	9311 1	11 5	.477	8568 9	9 0	.550	7980 1	7 3	.623	7497 9	6 1	.696	7094 0	5 1	.769	6748 9	4 4
.405	9299 6	11 5	.478	8559 9	9 0	.551	7972 9	7 2	.624	7491 9	6 0	.697	7088 9	5 1	.770	6744 5	4 4
.406	9288 1	11 5	.479	8551 0	8 9	.552	7965 6	7 3	.625	7485 9	6 0	.698	7083 8	5 1	.771	6740 1	4 4
.407	9276 7	11 4	.480	8542 1	8 9	.553	7958 4	7 2	.626	7479 9	6 0	.699	7078 7	5 1	.772	6735 7	4 4
.408	9265 3	11 4	.481	8533 2	8 9	.554	7951 3	7 1	.627	7474 0	5 9	.700	7073 7	5 0	.773	6731 4	4 3
.409	9254 0	11 3	.482	8524 4	8 8	.555	7944 1	7 2	.628	7468 0	6 0	.701	7068 6	5 1	.774	6727 0	4 4
.410	9242 7	11 3	.483	8515 5	8 9	.556	7937 0	7 1	.629	7462 1	5 9	.702	7063 6	5 0	.775	6722 7	4 3
.411	9231 4	11 3	.484	8506 8	8 7	.557	7929 8	7 2	.630	7456 2	5 9	.703	7058 5	5 1	.776	6718 4	4 3
.412	9220 2	11 2	.485	8498 0	8 8	.558	7922 7	7 1	.631	7450 3	5 9	.704	7053 5	5 0	.777	6714 1	4 3
.413	9209 1	11 1	.486	8489 3	8 7	.559	7915 7	7 0	.632	7444 4	5 9	.705	7048 5	5 0	.778	6709 7	4 4
.414	9197 9	11 2	.487	8480 6	8 7	.560	7908 6	7 1	.633	7438 5	5 9	.706	7043 5	5 0	.779	6705 4	4 3
.415	9186 8	11 1	.488	8471 9	8 7	.561	7901 6	7 0	.634	7432 6	5 9	.707	7038 5	5 0	.780	6701 1	4 3
.416	9175 8	11 0	.489	8463 2	8 7	.562	7894 5	7 1	.635	7426 8	5 8	.708	7033 5	5 0	.781	6696 8	4 3
.417	9164 8	11 0	.490	8454 6	8 6	.563	7887 5	7 0	.636	7421 0	5 8	.709	7028 6	4 9	.782	6692 6	4 2
.418	9153 8	11 0	.491	8446 0	8 6	.564	7880 6	6 9	.637	7415 1	5 9	.710	7023 6	5 0	.783	6688 3	4 3
.419	9142 9	10 9	.492	8437 4	8 6	.565	7873 6	7 0	.638	7409 3	5 8	.711	7018 6	5 0	.784	6684 0	4 3
.420	9132 0	10 9	.493	8428 9	8 5	.566	7866 6	7 0	.639	7403 5	5 8	.712	7013 7	4 9	.785	6679 7	4 3
.421	9121 2	10 8	.494	8420 4	8 5	.567	7859 7	6 9	.640	7397 8	5 7	.713	7008 8	4 9	.786	6675 5	4 2
.422	9110 3	10 9	.495	8411 9	8 5	.568	7852 8	6 9	.641	7392 0	5 8	.714	7003 9	4 9	.787	6671 2	4 3
.423	9099 6	10 7	.496	8403 4	8 5	.569	7845 9	6 9	.642	7386 3	5 7	.715	6998 9	5 0	.788	6667 0	4 2
0.424	9088 8	10 8	0.497	8394 9	8 5	0.570	7839 0	6 9	0.643	7380 5	5 8	0.716	6994 1	4 8	0.789	6662 8	4 2

TABLE I. — (CONTINUED.)

r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.
	0.000			0.000			0.000			0 000			0.000			0.000	
0.789	6662 8		0.862	6374 3		0.935	6120 5		1.08	5694 8		1.81	4399 0		2.54	3713 4	
.790	6658 6	4 2	.863	6370 6	3 7	.936	6117 2	3 3	.09	5668 6	26 2	.82	4386 9	12 1	.55	3706 1	7 3
.791	6654 4	4 2	.864	6367 0	3 6	.937	6114 0	3 2	.10	5642 9	25 7	.83	4374 9	12 0	.56	3698 9	7 2
.792	6650 2	4 2	.865	6363 3	3 7	.938	6110 7	3 3	.11	5617 4	25 5	.84	4363 0	11 9	.57	3691 7	7 2
.793	6646 0	4 2	.866	6359 6	3 7	.939	6107 5	3 2	.12	5592 3	25 1	.85	4351 2	11 8	.58	3684 5	7 2
.794	6641 9	4 1	.867	6356 0	3 6	.940	6104 2	3 3	.13	5567 6	24 7	.86	4339 4	11 8	.59	3677 4	7 1
.795	6637 7	4 2	.868	6352 3	3 7	.941	6101 0	3 2	.14	5543 1	24 5	.87	4327 8	11 6	.60	3670 3	7 1
.796	6633 5	4 2	.869	6348 6	3 7	.942	6097 7	3 3	.15	5518 9	24 2	.88	4316 3	11 5	.61	3 663 3	7 0
.797	6629 4	4 1	.870	6345 0	3 6	.943	6094 5	3 2	.16	5495 1	23 8	.89	4304 8	11 5	.62	3 656 3	7 0
.798	6625 2	4 2	.871	6341 4	3 6	.944	6091 3	3 2	.17	5471 5	23 6	.90	4293 5	11 3	.63	3 649 3	7 0
.799	6621 1	4 1	.872	6337 7	3 7	.945	6088 1	3 2	.18	5448 3	23 2	.91	4282 3	11 2	.64	3 642 4	6 9
.800	6616 9	4 2	.873	6334 1	3 6	.946	6084 9	3 2	.19	5425 3	23 0	.92	4271 1	11 2	.65	3 635 5	6 9
.801	6612 8	4 1	.874	6330 5	3 6	.947	6081 6	3 3	.20	5402 6	22 7	.93	4260 0	11 1	.66	3 628 7	6 8
.802	6608 7	4 1	.875	6326 9	3 6	.948	6078 4	3 2	.21	5380 3	22 3	.94	4249 0	11 0	.67	3 621 9	6 8
.803	6604 5	4 2	.876	6323 3	3 6	.949	6075 2	3 2	.22	5358 1	22 2	.95	4238 1	10 9	.68	3615 1	6 8
.804	6600 4	4 1	.877	6319 7	3 6	.950	6072 0	3 2	.23	5336 3	21 8	.96	4227 3	10 8	.69	3608 4	6 7
.805	6596 4	4 0	.878	6316 1	3 6	.951	6068 8	3 2	.24	5314 7	21 6	.97	4216 5	10 8	.70	3601 7	6 7
.806	6592 3	4 1	.879	6312 5	3 6	.952	6065 6	3 2	.25	5293 4	21 3	.98	4205 9	10 6	.71	3595 0	6 7
.807	6588 2	4 1	.880	6308 9	3 6	.953	6062 4	3 2	.26	5272 4	21 0	.99	4195 3	10 6	.72	3588 4	6 6
.808	6584 1	4 1	.881	6305 3	3 6	.954	6059 3	3 1	.27	5251 6	20 8	2.00	4184 8	10 5	.73	3581 9	6 5
.809	6580 0	4 1	.882	6301 6	3 7	.955	6056 1	3 2	.28	5231 0	20 6	.01	4174 4	10 4	.74	3575 3	6 6
.810	6575 9	4 1	.883	6298 2	3 4	.956	6052 9	3 2	.29	5210 7	20 3	.02	4164 1	10 3	.75	3568 8	6 5
.811	6571 8	4 1	.884	6294 7	3 5	.957	6049 8	3 1	.30	5190 6	20 1	.03	4153 8	10 3	.76	3562 4	6 4
.812	6567 8	4 0	.885	6291 1	3 6	.958	6046 6	3 2	.31	5170 7	19 9	.04	4143 6	10 2	.77	3556 0	6 4
.813	6563 8	4 0	.886	6287 5	3 6	.959	6043 5	3 1	.32	5151 1	19 6	.05	4133 5	10 1	.78	3549 5	6 5
.814	6559 7	4 1	.887	6283 9	3 6	.960	6040 3	3 2	.33	5131 7	19 4	.06	4123 5	10 0	.79	3543 2	6 3
.815	6555 7	4 0	.888	6280 4	3 5	.961	6037 2	3 1	.34	5112 5	19 2	.07	4113 5	10 0	.80	3536 8	6 4
.816	6551 7	4 0	.889	6276 8	3 6	.962	6034 0	3 2	.35	5093 5	19 0	.08	4103 6	9 9	.81	3530 5	6 3
.817	6547 7	4 0	.890	6273 3	3 5	.963	6030 9	3 1	.36	5074 8	18 7	.09	4093 8	9 8	.82	3524 2	6 3
.818	6543 7	4 0	.891	6269 8	3 5	.964	6027 8	3 1	.37	5056 2	18 6	.10	4084 0	9 8	.83	3518 0	6 2
.819	6539 7	4 0	.892	6266 3	3 5	.965	6024 6	3 2	.38	5037 9	18 3	.11	4074 3	9 7	.84	3511 8	6 2
.820	6535 6	4 1	.893	6262 7	3 6	.966	6021 5	3 1	.39	5019 7	18 2	.12	4064 7	9 6	.85	3505 6	6 2
.821	6531 6	4 0	.894	6259 2	3 5	.967	6018 4	3 1	.40	5001 8	17 9	.13	4055 2	9 5	.86	3499 5	6 1
.822	6527 6	4 0	.895	6255 7	3 5	.968	6015 3	3 1	.41	4984 0	17 8	.14	4045 7	9 5	.87	3493 4	6 1
.823	6523 7	3 9	.896	6252 2	3 5	.969	6012 2	3 1	.42	4966 4	17 6	.15	4036 3	9 4	.88	3487 3	6 1
.824	6519 7	4 0	.897	6248 7	3 5	.970	6009 1	3 1	.43	4949 6	17 4	.16	4026 9	9 4	.89	3481 3	6 0
.825	6515 7	4 0	.898	6245 3	3 4	.971	6006 0	3 1	.44	4931 8	17 2	.17	4017 6	9 3	.90	3475 3	6 0
.826	6511 8	3 9	.899	6241 8	3 5	.972	6002 9	3 1	.45	4914 8	17 0	.18	4008 4	9 2	.91	3469 3	6 0
.827	6507 9	3 9	.900	6238 3	3 5	.973	5999 8	3 1	.46	4897 9	16 9	.19	3999 3	9 1	.92	3463 4	5 9
.828	6503 9	4 0	.901	6234 8	3 5	.974	5996 7	3 1	.47	4881 2	16 7	.20	3990 1	9 2	.93	3457 5	5 9
.829	6500 0	3 9	.902	6231 4	3 4	.975	5993 6	3 1	.48	4864 7	16 5	.21	3981 1	9 0	.94	3451 6	5 9
.830	6496 0	4 0	.903	6227 9	3 5	.976	5990 6	3 0	.49	4848 4	16 3	.22	3972 1	9 0	.95	3445 8	5 8
.831	6492 1	3 9	.904	6224 5	3 4	.977	5987 5	3 1	.50	4832 2	16 2	.23	3963 2	8 9	.96	3439 9	5 9
.832	6488 2	3 9	.905	6221 0	3 5	.978	5984 4	3 1	.51	4816 2	16 0	.24	3954 3	8 9	.97	3434 1	5 8
.833	6484 3	3 9	.906	6217 6	3 4	.979	5981 4	3 0	.52	4800 3	15 9	.25	3945 5	8 8	.98	3428 4	5 7
.834	6480 4	3 9	.907	6214 1	3 5	.980	5978 3	3 1	.53	4784 6	15 7	.26	3936 8	8 7	.99	3422 6	5 8
.835	6476 5	3 9	.908	6210 7	3 4	.981	5975 3	3 0	.54	4769 1	15 5	.27	3928 0	8 8	3.00	3416 9	5 7
.836	6472 6	3 9	.909	6207 3	3 4	.982	5972 2	3 1	.55	4753 7	15 4	.28	3919 4	8 6	.01	3411 2	5 7
.837	6468 8	3 8	.910	6203 9	3 4	.983	5969 2	3 0	.56	4738 4	15 3	.29	3910 9	8 5	.02	3405 6	5 6
.838	6464 9	3 9	.911	6200 5	3 4	.984	5966 1	3 1	.57	4723 3	15 1	.30	3902 4	8 5	.03	3399 9	5 7
.839	6461 1	3 8	.912	6197 1	3 4	.985	5963 1	3 0	.58	4708 3	15 0	.31	3893 9	8 5	.04	3394 3	5 6
.840	6457 2	3 9	.913	6193 7	3 4	.986	5960 1	3 0	.59	4693 5	14 8	.32	3885 5	8 4	.05	3388 8	5 5
.841	6453 4	3 8	.914	6190 3	3 4	.987	5957 0	3 1	.60	4678 8	14 7	.33	3877 0	8 5	.06	3383 2	5 6
.842	6449 5	3 9	.915	6186 9	3 4	.988	5954 0	3 0	.61	4664 3	14 5	.34	3868 9	8 1	.07	3377 7	5 5
.843	6445 7	3 8	.916	6183 6	3 3	.989	5951 0	3 0	.62	4649 8	14 5	.35	3860 6	8 3	.08	3372 2	5 5
.844	6441 9	3 8	.917	6180 2	3 4	.990	5948 0	3 0	.63	4635 5	14 3	.36	3852 4	8 2	.09	3366 7	5 5
.845	6438 1	3 8	.918	6176 8	3 4	.991	5945 0	3 0	.64	4621 4	14 1	.37	3844 3	8 1	.10	3361 3	5 4
.846	6434 3	3 8	.919	6173 5	3 3	.992	5942 0	3 0	.65	4607 4	14 0	.38	3836 3	8 0	.11	3355 9	5 4
.847	6430 5	3 8	.920	6170 1	3 4	.993	5939 0	3 0	.66	4593 5	13 9	.39	3828 2	8 1	.12	3350 5	5 4
.848	6426 7	3 8	.921	6166 8	3 3	.994	5936 0	3 0	.67	4579 7	13 8	.40	3820 2	8 0	.13	3345 1	5 4
.849	6422 9	3 8	.922	6163 4	3 4	.995	5933 0	3 0	.68	4566 0	13 7	.41	3812 3	7 9	.14	3339 8	5 3
.850	6419 1	3 8	.923	6160 1	3 3	.996	5930 1	2 9	.69	4552 5	13 5	.42	3804 4	7 9	.15	3334 5	5 3
.851	6415 3	3 8	.924	6156 8	3 3	.997	5927 1	3 0	.70	4539 1	13 4	.43	3796 6	7 8	.16	3329 2	5 3
.852	6411 6	3 7	.925	6153 4	3 4	.998	5924 1	3 0	.71	4525 8	13 3	.44	3788 7	7 9	.17	3324 0	5 2
.853	6407 8	3 8	.926	6150 1	3 3	.999	5921 2	2 9	.72	4512 6	13 2	.45	3781 0	7 7	.18	3318 8	5 2
.854	6404 1	3 7	.927	6146 8	3 3	1.000	5918 2	3 0	.73	4499 6	13 0	.46	3773 3	7 7	.19	3313 6	5 2
.855	6400 4	3 7	.928	6143 5	3 3	.010	5888 8	29 4	.74	4486 6	13 0	.47	3765 6	7 7	.20	3308 4	5 2
.856	6396 6	3 8	.929	6140 2	3 3	.020	5859 9	28 9	.75	4473 8	12 8	.48	3758 0	7 6	.21	3303 2	5 2
.857	6392 9	3 7	.930	6136 9	3 3	.030	5831 4	28 5	.76	4461 0	12 8	.49	3750 5	7 5	.22	3298 1	5 1
.858	6389 2	3 7	.931	6133 6	3 3	.040	5803 3	28 1	.77	4448 4	12 6	.50	3743 0	7 5	.23	3293 0	5 1
.859	6385 5	3 7	.932	6130 3	3 3	.050	5775 6	27 7	.78	4435 9	12 5	.51	3735 5	7 5	.24	3287 9	5 1
.860	6381 7	3 8	.933	6127 0	3 3	.060	5748 3	27 3	.79	4423 5	12 4	.52	3728 1	7 4	.25	3282 9	5 0
.861	6378 0	3 7	.934	6123 8	3 2	.070	5721 4	26 9	.80	4411 2	12 3	.53	3720 7	7 4	.26	3277 8	5 1
0 862	6374 3	3 7	0.935	6120 5	3 3	1.080	5694 8	26 6	1.81	4399 0	12 2	2.54	3713 4	7 3	3.27	3272 8	5 0

TABLE I.—(CONTINUED.)

r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.	r^2	$\frac{2\mu}{r}$	Dif.
	0.000			0.000			0.000			0.000			0.000			0.000	
3.27	3272 8		3.65	3097 8		4.02	2951 7		4.39	2824 6		4.76	2712 7		6.30	2357 9	
.28	3267 8	5 0	.66	3093 5	4 3	.03	2948 1	3 6	.40	2821 4	3 2	.77	2709 9	2 8	.40	2339 4	18 5
.29	3262 8	5 0	.67	3089 3	4 2	.04	2944 4	3 7	.41	2818 2	3 2	.78	2707 0	2 9	.50	2321 3	18 1
.30	3257 9	4 9	.68	3085 1	4 2	.05	2940 8	3 6	.42	2815 0	3 2	.79	2704 2	2 8	.60	2303 7	17 6
.31	3253 0	4 9	.69	3080 9	4 2	.06	2937 2	3 6	.43	2811 8	3 2	.80	2701 3	2 9	.70	2286 5	17 2
.32	3248 1	4 9	.70	3076 8	4 1	.07	2933 5	3 7	.44	2808 7	3 1	.81	2698 5	2 8	.80	2269 6	16 9
.33	3243 2	4 9	.71	3072 6	4 2	.08	2930 0	3 5	.45	2805 5	3 2	.82	2695 7	2 8	6.90	2253 0	16 6
.34	3238 3	4 9	.72	3068 5	4 1	.09	2926 4	3 6	.46	2802 4	3 1	.83	2692 9	2 8	7.00	2236 8	16 2
.35	3233 5	4 8	.73	3064 4	4 1	.10	2922 8	3 6	.47	2799 2	3 2	.84	2690 2	2 7	.10	2221 0	15 8
.36	3228 7	4 8	.74	3060 3	4 1	.11	2919 3	3 5	.48	2796 1	3 1	.85	2687 4	2 8	.20	2205 6	15 4
.37	3223 9	4 8	.75	3056 2	4 1	.12	2915 7	3 6	.49	2792 0	3 1	.86	2684 6	2 8	.30	2190 4	15 2
.38	3219 1	4 8	.76	3052 1	4 1	.13	2912 2	3 5	.50	2789 9	3 1	.87	2681 9	2 7	.40	2175 6	14 8
.39	3214 3	4 8	.77	3048 1	4 0	.14	2908 7	3 5	.51	2786 8	3 1	.88	2679 1	2 8	.50	2161 0	14 6
.40	3209 6	4 7	.78	3044 0	4 1	.15	2905 2	3 5	.52	2783 7	3 1	.89	2676 4	2 7	.60	2146 8	14 2
.41	3204 9	4 7	.79	3040 0	4 0	.16	2901 7	3 5	.53	2780 7	3 0	.90	2673 6	2 8	.70	2132 8	14 0
.42	3200 2	4 7	.80	3036 0	4 0	.17	2898 2	3 5	.54	2777 6	3 1	.91	2670 9	2 7	.80	2119 1	13 7
.43	3195 5	4 7	.81	3032 0	4 0	.18	2894 7	3 5	.55	2774 6	3 0	.92	2668 2	2 7	7.90	2105 6	13 5
.44	3190 9	4 6	.82	3028 0	4 0	.19	2891 3	3 4	.56	2771 5	3 1	.93	2665 5	2 7	8.00	2092 4	13 2
.45	3186 3	4 6	.83	3024 1	3 9	.20	2887 8	3 5	.57	2768 5	3 0	.94	2662 8	2 7	.10	2079 5	12 9
.46	3181 7	4 6	.84	3020 1	4 0	.21	2884 4	3 4	.58	2765 5	3 0	.95	2660 1	2 7	.20	2066 8	12 7
.47	3177 1	4 6	.85	3016 2	3 9	.22	2881 0	3 4	.59	2762 5	3 0	.96	2657 4	2 7	.30	2054 3	12 5
.48	3172 5	4 6	.86	3012 3	3 9	.23	2877 5	3 5	.60	2759 4	3 1	.97	2654 7	2 7	.40	2042 0	12 3
.49	3167 9	4 6	.87	3008 4	3 9	.24	2874 1	3 4	.61	2756 4	3 0	.98	2652 1	2 6	.50	2029 9	12 1
.50	3163 4	4 5	.88	3004 5	3 9	.25	2870 8	3 3	.62	2753 4	3 0	4.99	2649 4	2 7	.60	2018 1	11 8
.51	3158 9	4 5	.89	3000 7	3 8	.26	2867 4	3 4	.63	2750 5	2 9	5.00	2646 7	2 7	.70	2006 4	11 7
.52	3154 4	4 5	.90	2996 8	3 9	.27	2864 0	3 4	.64	2747 5	3 0	.10	2620 6	26 1	.80	1995 0	11 4
.53	3149 9	4 5	.91	2993 0	3 8	.28	2860 7	3 3	.65	2744 6	2 9	.20	2595 3	25 3	8.90	1983 8	11 2
.54	3145 5	4 4	.92	2989 1	3 9	.29	2857 3	3 4	.66	2741 6	3 0	.30	2570 7	24 6	9.00	1972 7	11 1
.55	3141 1	4 4	.93	2985 4	3 7	.30	2854 0	3 3	.67	2738 7	2 9	.40	2546 8	23 9	.10	1961 9	10 8
.56	3136 6	4 5	.94	2981 6	3 8	.31	2850 7	3 3	.68	2735 8	2 9	.50	2523 6	23 2	.20	1951 2	10 7
.57	3132 2	4 4	.95	2977 8	3 8	.32	2847 4	3 3	.69	2732 9	2 9	.60	2501 0	22 6	.30	1940 6	10 6
.58	3127 9	4 3	.96	2974 0	3 8	.33	2844 1	3 3	.70	2729 9	3 0	.70	2478 9	22 1	.40	1930 3	10 3
.59	3123 5	4 4	.97	2970 3	3 7	.34	2840 8	3 3	.71	2727 0	2 9	.80	2457 4	21 5	.50	1920 1	10 2
.60	3119 2	4 3	.98	2966 6	3 7	.35	2837 6	3 2	.72	2724 1	2 9	5.90	2436 5	20 9	.60	1910 1	10 0
.61	3114 9	4 3	3 99	2962 9	3 7	.36	2834 3	3 3	.73	2721 3	2 8	6.00	2416 1	20 4	.70	1900 3	9 8
.62	3110 6	4 3	4.00	2959 1	3 8	.37	2831 1	3 2	.74	2718 4	2 9	.10	2396 2	19 9	.80	1890 5	9 8
.63	3106 3	4 3	.01	2955 4	3 7	.38	2827 8	3 3	.75	2715 5	2 9	.20	2376 8	19 4	9.90	1880 9	9 6
.64	3102 0	4 3	4.02	2951 7	3 7	4.39	2824 6	3 2	4.76	2712 7	2 8	6.30	2357 9	18 9	10.00	1871 5	9 4
3.65	3097 8	4 2															

TABLE II.

r^2	$\log. \frac{\mu}{r^3}$	Dif.	r^2	$\log. \frac{\mu}{r^3}$	Dif.	r^2	$\log. \frac{\mu}{r^3}$	Dif.	r^2	$\log. \frac{\mu}{r^3}$	Dif.	r^2	$\log. \frac{\mu}{r^3}$	Dif.	r^2	$\log. \frac{\mu}{r^3}$	Dif.
0.351	7.15320		0.375	7.11012		0.399	7.06970		0.423	7.03165		0.447	7.99571		0.471	6 96163	
.352	.15135	185	.376	.10838	174	.400	.06807	163	.424	.03011	154	.448	.99425	146	.472	.96025	138
.353	.14950	185	.377	.10665	173	.401	.06644	163	.425	.02858	153	.449	.99280	145	.473	.95887	138
.354	.14766	184	.378	.10493	172	.402	.06482	162	.426	.02704	154	.450	.99135	145	.474	.95749	138
.355	.14582	184	.379	.10321	172	.403	.06320	162	.427	.02552	152	.451	.98990	145	.475	.95612	137
.356	.14399	183	.380	.10149	172	.404	.06159	161	.428	.02399	153	.452	.98846	144	.476	.95475	137
.357	.14216	183	.381	.09978	171	.405	.05998	161	.429	.02247	152	.453	.98702	144	.477	.95338	137
.358	.14034	182	.382	.09807	171	.406	.05837	161	.430	.02096	151	.454	.98558	144	.478	.95202	136
.359	.13852	182	.383	.09637	170	.407	.05677	160	.431	.01945	151	.455	.98415	143	.479	.95066	136
.360	.13671	181	.384	.09467	170	.408	.05517	160	.432	.01794	151	.456	.98271	144	.480	.94930	136
.361	.13490	181	.385	.09297	170	.409	.05358	159	.433	.01643	151	.457	.98128	143	.481	.94795	135
.362	.13310	180	.386	.09128	169	.410	.05199	159	.434	.01493	150	.458	.97986	142	.482	.94659	136
.363	.13130	180	.387	.08960	168	.411	.05040	159	.435	.01343	150	.459	.97844	142	.483	.94524	135
.364	.12951	179	.388	.08792	168	.412	.04882	158	.436	.01193	150	.460	.97702	142	.484	.94390	134
.365	.12772	179	.389	.08624	168	.413	.04724	158	.437	.01044	149	.461	.97560	142	.485	.94255	135
.366	.12594	178	.390	.08457	167	.414	.04567	157	.438	.00895	149	.462	.97419	141	.486	.94121	134
.367	.12417	177	.391	.08290	167	.415	.04409	158	.439	.00747	148	.463	.97278	141	.487	.93988	133
.368	.12239	178	.392	.08124	166	.416	.04253	156	.440	.00599	148	.464	.97137	141	.488	.93854	134
.369	.12063	176	.393	.07958	166	.417	.04096	157	.441	.00451	148	.465	.96997	140	.489	.93721	133
.370	.11886	177	.394	.07792	166	.418	.03940	156	.442	.00304	147	.466	.96857	140	.490	.93587	134
.371	.11710	176	.395	.07627	165	.419	.03784	156	.443	.00156	148	.467	.96717	140	.491	.93454	133
.372	.11535	175	.396	.07462	165	.420	.03629	155	.444	.00010	146	.468	.96578	139	.492	.93322	132
.373	.11360	175	.397	.07298	164	.421	.03474	155	.445	.99863	147	.469	.96439	139	.493	.93190	132
.374	.11186	174	.398	.07134	164	.422	.03319	155	.446	.99717	146	.470	7.96301	138	.494	.93058	132
0.375	7.11012	174	0.399	7.06970	164	0.423	7.03165	154	0.447	7.99571	146	0.471	6.96163	138	0.495	6.92926	131

TABLE II. — (CONTINUED.)

r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.
0 495	6.92026		0.568	6.83964		0.641	6.76087		0.714	6.69061		0.787	6.62720		0.860	6.56941	
.496	.92795	131	.569	.83849	115	.642	.75985	102	.715	.68970	91	.788	.62637	83	.861	.56865	76
.497	.92664	131	.570	.83735	114	.643	.75884	101	.716	.68879	91	.789	.62554	83	.862	.56790	75
.498	.92533	131	.571	.83621	114	.644	.75783	101	.717	.68788	91	.790	.62472	82	.863	.56714	76
.499	.92402	131	.572	.83507	114	.645	.75682	101	.718	.68697	91	.791	.62390	82	.864	.56639	75
.500	.92271	131	.573	.83393	114	.646	.75581	101	.719	.68606	91	.792	.62307	83	.865	.56564	75
.501	.92141	130	.574	.83279	114	.647	.75480	101	.720	.68516	90	.793	.62225	82	.866	.56489	75
.502	.92011	130	.575	.83166	113	.648	.75380	100	.721	.68426	90	.794	.62143	82	.867	.56414	75
.503	.91882	129	.576	.83053	113	.649	.75280	100	.722	.68335	91	.795	.62061	82	.868	.56339	75
.504	.91752	130	.577	.82940	113	.650	.75180	99	.723	.68245	90	.796	.61979	82	.869	.56264	75
.505	.91623	129	.578	.82827	113	.651	.75079	101	.724	.68155	90	.797	.61897	82	.870	.56188	76
.506	.91495	128	.579	.82714	113	.652	.74979	100	.725	.68065	90	.798	.61816	81	.871	.56113	75
.507	.91366	129	.580	.82602	112	.653	.74880	99	.726	.67976	89	.799	.61734	82	.872	.56039	74
.508	.91238	128	.581	.82490	112	.654	.74780	100	.727	.67886	90	.800	.61653	81	.873	.55964	75
.509	.91109	129	.582	.82378	112	.655	.74680	100	.728	.67796	90	.801	.61572	82	.874	.55890	74
.510	.90981	128	.583	.82266	112	.656	.74581	99	.729	.67707	89	.802	.61490	81	.875	.55815	75
.511	.90853	127	.584	.82154	112	.657	.74482	99	.730	.67618	89	.803	.61409	81	.876	.55741	74
.512	.90726	127	.585	.82043	111	.658	.74383	99	.731	.67529	89	.804	.61328	81	.877	.55667	74
.513	.90599	127	.586	.81932	111	.659	.74284	99	.732	.67440	89	.805	.61247	81	.878	.55593	74
.514	.90472	127	.587	.81821	111	.660	.74185	99	.733	.67351	89	.806	.61166	81	.879	.55519	74
.515	.90346	126	.588	.81710	111	.661	.74086	99	.734	.67262	89	.807	.61085	80	.880	.55444	75
.516	.90219	127	.589	.81599	111	.662	.73987	99	.735	.67173	89	.808	.61005	81	.881	.55370	74
.517	.90093	126	.590	.81489	110	.663	.73889	98	.736	.67085	88	.809	.60924	80	.882	.55296	74
.518	.89967	125	.591	.81379	110	.664	.73791	98	.737	.66996	89	.810	.60844	80	.883	.55223	73
.519	.89842	126	.592	.81269	110	.665	.73693	98	.738	.66908	88	.811	.60764	81	.884	.55149	74
.520	.89716	125	.593	.81159	110	.666	.73595	98	.739	.66820	88	.812	.60683	80	.885	.55075	74
.521	.89591	125	.594	.81049	110	.667	.73497	98	.740	.66732	88	.813	.60603	80	.886	.55002	73
.522	.89466	125	.595	.80939	110	.668	.73399	98	.741	.66644	88	.814	.60523	80	.887	.54928	74
.523	.89341	125	.596	.80830	109	.669	.73302	97	.742	.66556	88	.815	.60443	80	.888	.54855	73
.524	.89216	125	.597	.80721	109	.670	.73205	97	.743	.66468	88	.816	.60363	80	.889	.54782	73
.525	.89091	125	.598	.80612	109	.671	.73108	97	.744	.66380	88	.817	.60283	80	.890	.54708	74
.526	.88967	124	.599	.80503	109	.672	.73011	97	.745	.66293	87	.818	.60204	79	.891	.54635	73
.527	.88843	124	.600	.80394	109	.673	.72914	97	.746	.66205	88	.819	.60124	80	.892	.54562	73
.528	.88720	123	.601	.80285	109	.674	.72817	97	.747	.66118	87	.820	.60045	79	.893	.54489	73
.529	.88597	123	.602	.80177	108	.675	.72720	97	.748	.66031	87	.821	.59966	79	.894	.54417	72
.530	.88474	123	.603	.80069	108	.676	.72624	96	.749	.65943	88	.822	.59886	80	.895	.54344	73
.531	.88351	123	.604	.79961	108	.677	.72528	96	.750	.65857	86	.823	.59807	79	.896	.54271	73
.532	.88229	122	.605	.79853	108	.678	.72431	97	.751	.65770	87	.824	.59728	79	.897	.54199	72
.533	.88106	123	.606	.79746	107	.679	.72335	96	.752	.65683	87	.825	.59649	79	.898	.54126	73
.534	.87984	122	.607	.79638	108	.680	.72240	95	.753	.65597	86	.826	.59570	79	.899	.54054	72
.535	.87863	121	.608	.79531	107	.681	.72144	95	.754	.65511	86	.827	.59492	78	.900	.53980	74
.536	.87741	122	.609	.79424	107	.682	.72049	95	.755	.65424	87	.828	.59413	79	.901	.53908	72
.537	.87620	121	.610	.79317	107	.683	.71953	96	.756	.65338	86	.829	.59334	79	.902	.53835	73
.538	.87499	121	.611	.79210	107	.684	.71858	95	.757	.65252	86	.830	.59254	80	.903	.53763	72
.539	.87378	121	.612	.79104	106	.685	.71763	95	.758	.65166	86	.831	.59175	79	.904	.53691	72
.540	.87257	121	.613	.78997	107	.686	.71668	95	.759	.65080	86	.832	.59097	78	.905	.53619	72
.541	.87137	120	.614	.78891	106	.687	.71573	95	.760	.64995	85	.833	.59019	78	.906	.53547	72
.542	.87016	121	.615	.78785	106	.688	.71478	95	.761	.64909	86	.834	.58941	78	.907	.53476	71
.543	.86896	120	.616	.78679	106	.689	.71383	95	.762	.64824	85	.835	.58863	78	.908	.53404	72
.544	.86777	119	.617	.78574	105	.690	.71289	94	.763	.64738	86	.836	.58785	78	.909	.53332	72
.545	.86657	120	.618	.78468	106	.691	.71195	94	.764	.64653	85	.837	.58707	78	.910	.53260	72
.546	.86538	119	.619	.78363	105	.692	.71100	95	.765	.64567	86	.838	.58629	78	.911	.53188	72
.547	.86419	119	.620	.78258	105	.693	.71006	94	.766	.64482	85	.839	.58552	77	.912	.53117	71
.548	.86300	119	.621	.78153	105	.694	.70912	94	.767	.64397	85	.840	.58474	78	.913	.53046	71
.549	.86181	119	.622	.78048	105	.695	.70818	94	.768	.64312	85	.841	.58396	78	.914	.52975	71
.550	.86062	118	.623	.77943	105	.696	.70724	94	.769	.64227	85	.842	.58319	78	.915	.52903	72
.551	.85944	118	.624	.77839	104	.697	.70631	93	.770	.64143	84	.843	.58242	77	.916	.52832	71
.552	.85826	118	.625	.77735	104	.698	.70537	94	.771	.64058	85	.844	.58165	77	.917	.52761	71
.553	.85708	118	.626	.77630	105	.699	.70444	93	.772	.63974	84	.845	.58088	77	.918	.52690	71
.554	.85590	118	.627	.77526	104	.700	.70351	93	.773	.63889	85	.846	.58010	78	.919	.52619	71
.555	.85472	118	.628	.77422	104	.701	.70258	93	.774	.63805	84	.847	.57933	77	.920	.52548	71
.556	.85355	117	.629	.77319	103	.702	.70165	93	.775	.63721	84	.848	.57856	77	.921	.52477	71
.557	.85238	117	.630	.77215	104	.703	.70072	93	.776	.63637	84	.849	.57779	77	.922	.52406	71
.558	.85121	117	.631	.77112	103	.704	.69980	92	.777	.63553	84	.850	.57703	76	.923	.52336	70
.559	.85004	117	.632	.77008	104	.705	.69887	93	.778	.63469	84	.851	.57626	77	.924	.52265	71
.560	.84888	116	.633	.76905	103	.706	.69795	92	.779	.63385	84	.852	.57550	76	.925	.52195	70
.561	.84772	116	.634	.76802	103	.707	.69703	92	.780	.63302	83	.853	.57474	76	.926	.52125	70
.562	.84656	116	.635	.76700	102	.708	.69611	92	.781	.63218	84	.854	.57397	77	.927	.52054	71
.563	.84540	116	.636	.76597	103	.709	.69519	92	.782	.63135	83	.855	.57321	76	.928	.51984	70
.564	.84424	116	.637	.76495	102	.710	.69427	92	.783	.63052	83	.856	.57245	76	.929	.51914	70
.565	.84309	115	.638	.76393	102	.711	.69335	92	.784	.62968	84	.857	.57168	77	.930	.51844	70
.566	.84193	116	.639	.76291	102	.712	.69244	91	.785	.62885	83	.858	.57092	76	.931	.51774	70
.567	.84078	115	.640	.76189	102	.713	.69152	92	.786	.62802	83	.859	.57017	75	.932	.51704	70
0.568	6.83964	114	0 641	6 76087	102	0.714	6.69061	91	0.787	6.62720	82	0.860	6 56941	76	0 933	6.51634	70

TABLE II.—(CONTINUED.)

r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.
0.933	6.51634		1.06	6.43320		1.79	6.09189		2.52	5.86906		3.25	5.70334		3.98	5.57134	
.934	.51564	70	.07	.42709	611	.80	.08826	363	.53	.86648	258	.26	.70134	200	3.99	.56970	164
.935	.51495	69	.08	.42103	606	.81	.08465	361	.54	.86391	257	.27	.69934	200	4.00	.56807	163
.936	.51425	70	.09	.41503	600	.82	.08106	359	.55	.86135	256	.28	.69736	198	.01	.56644	163
.937	.51356	69	.10	.40908	595	.83	.07749	357	.56	.85880	255	.29	.69537	199	.02	.56482	162
.938	.51286	70	.11	.40318	590	.84	.07394	355	.57	.85626	254	.30	.69340	197	.03	.56320	162
.939	.51217	69	.12	.39733	585	.85	.07041	353	.58	.85373	253	.31	.69143	197	.04	.56159	161
.940	.51147	70	.13	.39154	579	.86	.06690	351	.59	.85121	252	.32	.68946	197	.05	.55998	161
.941	.51078	69	.14	.38580	574	.87	.06340	350	.60	.84871	250	.33	.68750	196	.06	.55837	161
.942	.51009	69	.15	.38011	569	.88	.05993	347	.61	.84621	250	.34	.68555	195	.07	.55677	160
.943	.50940	69	.16	.37447	564	.89	.05647	346	.62	.84372	249	.35	.68360	195	.08	.55517	160
.944	.50871	69	.17	.36888	559	.90	.05304	343	.63	.84123	249	.36	.68166	194	.09	.55358	159
.945	.50802	69	.18	.36334	554	.91	.04962	342	.64	.83876	247	.37	.67972	194	.10	.55199	159
.946	.50733	69	.19	.35784	550	.92	.04622	340	.65	.83630	246	.38	.67779	193	.11	.55040	159
.947	.50664	69	.20	.35239	555	.93	.04283	339	.66	.83384	246	.39	.67586	193	.12	.54882	158
.948	.50595	69	.21	.34698	541	.94	.03947	336	.67	.83140	244	.40	.67394	192	.13	.54724	158
.949	.50527	68	.22	.34162	536	.95	.03612	335	.68	.82896	244	.41	.67203	191	.14	.54567	157
.950	.50458	69	.23	.33630	532	.96	.03278	334	.69	.82654	242	.42	.67012	191	.15	.54409	158
.951	.50389	69	.24	.33103	527	.97	.02947	331	.70	.82412	242	.43	.66821	191	.16	.54253	156
.952	.50321	68	.25	.32580	523	.98	.02617	330	.71	.82171	241	.44	.66632	189	.17	.54076	157
.953	.50253	68	.26	.32061	519	1.99	.02288	329	.72	.81931	240	.45	.66442	190	.18	.53940	156
.954	.50185	68	.27	.31546	515	2.00	.01962	326	.73	.81692	239	.46	.66254	188	.19	.53784	156
.955	.50116	69	.28	.31035	511	.01	.01637	325	.74	.81454	238	.47	.66066	188	.20	.53629	155
.956	.50048	68	.29	.30528	507	.02	.01314	323	.75	.81216	238	.48	.65879	187	.21	.53474	155
.957	.49980	68	.30	.30025	503	.03	.00992	322	.76	.80980	236	.49	.65692	187	.22	.53319	155
.958	.49912	68	.31	.29526	499	.04	.00671	321	.77	.80744	236	.50	.65506	186	.23	.53165	154
.959	.49844	68	.32	.29031	495	.05	.00353	318	.78	.80509	235	.51	.65320	186	.24	.53011	154
.960	.49776	68	.33	.28539	492	.06	6.00035	318	.79	.80275	234	.52	.65135	185	.25	.52858	153
.961	.49708	68	.34	.28051	488	.07	5.99720	315	.80	.80042	233	.53	.64950	185	.26	.52704	154
.962	.49641	67	.35	.27566	485	.08	.99406	314	.81	.79810	232	.54	.64766	184	.27	.52552	152
.963	.49573	68	.36	.27086	480	.09	.99093	313	.82	.79578	232	.55	.64582	184	.28	.52399	153
.964	.49505	68	.37	.26608	478	.10	.98783	310	.83	.79348	230	.56	.64399	183	.29	.52247	152
.965	.49438	67	.38	.26135	473	.11	.98473	310	.84	.79118	230	.57	.64216	183	.30	.52096	151
.966	.49371	67	.39	.25664	471	.12	.98166	307	.85	.78889	229	.58	.64034	182	.31	.51945	151
.967	.49303	68	.40	.25197	467	.13	.97859	307	.86	.78661	228	.59	.63852	182	.32	.51794	151
.968	.49236	67	.41	.24734	463	.14	.97554	305	.87	.78433	228	.60	.63671	181	.33	.51643	151
.969	.49169	67	.42	.24273	461	.15	.97250	304	.88	.78207	226	.61	.63490	181	.34	.51493	150
.970	.49101	68	.43	.23816	457	.16	.96948	302	.89	.77981	226	.62	.63310	180	.35	.51343	150
.971	.49034	67	.44	.23363	453	.17	.96647	301	.90	.77756	225	.63	.63130	180	.36	.51193	150
.972	.48967	67	.45	.22912	451	.18	.96347	300	.91	.77532	224	.64	.62951	179	.37	.51044	149
.973	.48900	67	.46	.22464	448	.19	.96049	298	.92	.77308	224	.65	.62772	179	.38	.50895	149
.974	.48832	68	.47	.22020	444	.20	.95753	296	.93	.77086	222	.66	.62594	178	.39	.50747	148
.975	.48765	67	.48	.21578	442	.21	.95458	295	.94	.76864	222	.67	.62417	177	.40	.50599	148
.976	.48698	67	.49	.21139	439	.22	.95164	294	.95	.76642	222	.68	.62239	178	.41	.50451	148
.977	.48632	66	.50	.20703	436	.23	.94871	293	.96	.76422	220	.69	.62063	176	.42	.50304	147
.978	.48565	67	.51	.20270	433	.24	.94579	292	.97	.76202	220	.70	.61886	177	.43	.50156	148
.979	.48498	67	.52	.19840	430	.25	.94289	290	.98	.75983	219	.71	.61710	176	.44	.50010	146
.980	.48432	66	.53	.19413	427	.26	.94001	288	2.99	.75765	218	.72	.61535	175	.45	.49863	147
.981	.48365	67	.54	.18989	424	.27	.93713	288	3.00	.75548	217	.73	.61360	175	.46	.49717	146
.982	.48299	66	.55	.18567	422	.28	.93427	286	.01	.75331	217	.74	.61186	174	.47	.49571	146
.983	.48233	66	.56	.18148	419	.29	.93142	285	.02	.75115	216	.75	.61012	174	.48	.49425	146
.984	.48166	67	.57	.17732	416	.30	.92858	284	.03	.74900	215	.76	.60838	174	.49	.49280	145
.985	.48100	66	.58	.17318	414	.31	.92575	283	.04	.74685	215	.77	.60665	173	.50	.49135	145
.986	.48034	66	.59	.16907	411	.32	.92294	281	.05	.74472	213	.78	.60493	172	.51	.48990	145
.987	.47968	66	.60	.16499	408	.33	.92014	280	.06	.74258	214	.79	.60321	172	.52	.48846	144
.988	.47902	66	.61	.16093	406	.34	.91735	279	.07	.74046	212	.80	.60149	172	.53	.48702	144
.989	.47836	66	.62	.15690	403	.35	.91457	278	.08	.73834	212	.81	.59978	171	.54	.48558	144
.990	.47770	66	.63	.15289	401	.36	.91180	277	.09	.73623	211	.82	.59807	171	.55	.48415	143
.991	.47704	66	.64	.14890	399	.37	.90905	275	.10	.73412	211	.83	.59637	170	.56	.48271	144
.992	.47638	66	.65	.14494	396	.38	.90630	275	.11	.73202	210	.84	.59467	170	.57	.48128	143
.993	.47573	65	.66	.14100	394	.39	.90357	273	.12	.72993	209	.85	.59297	170	.58	.47986	142
.994	.47507	66	.67	.13709	391	.40	.90085	272	.13	.72785	208	.86	.59128	169	.59	.47844	142
.995	.47442	65	.68	.13320	389	.41	.89814	271	.14	.72577	208	.87	.58960	168	.60	.47702	142
.996	.47377	65	.69	.12933	387	.42	.89544	270	.15	.72370	207	.88	.58792	168	.61	.47560	142
.997	.47311	66	.70	.12549	384	.43	.89276	268	.16	.72163	207	.89	.58624	168	.62	.47419	141
.998	.47246	65	.71	.12167	382	.44	.89008	268	.17	.71957	206	.90	.58457	167	.63	.47278	141
0.999	.47181	65	.72	.11787	380	.45	.88742	266	.18	.71752	205	.91	.58290	167	.64	.47137	141
1.000	.47116	65	.73	.11410	377	.46	.88476	266	.19	.71548	204	.92	.58124	166	.65	.46997	140
.010	.46468	648	.74	.11034	376	.47	.88212	264	.20	.71344	204	.93	.57958	166	.66	.46857	140
.020	.45826	642	.75	.10661	373	.48	.87949	263	.21	.71141	203	.94	.57792	166	.67	.46717	140
.030	.45190	636	.76	.10290	371	.49	.87687	262	.22	.70938	203	.95	.57627	165	.68	.46578	139
.040	.44561	629	.77	.09921	369	.50	.87425	262	.23	.70736	202	.96	.57462	165	.69	.46439	139
.050	.43938	623	.78	.09554	367	.51	.87165	260	.24	.70535	201	.97	.57298	164	.70	.46301	138
1.060	6.43320	618	1.79	6.09189	365	2.52	5.86906	259	3.25	5.70334	201	3.98	5.57134	164	4.71	5.46163	138

TABLE II. — (CONTINUED.)

r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.	r^2	$\log \frac{\mu}{r^3}$	Dif.
4.71	5.46163		5.04	5.41752		5.37	5.37620		5.70	5.33735		6.03	5.30069		6.36	5.26597	
.72	.46025	138	.05	.41623	129	.38	.37499	121	.71	.33621	114	.04	.29961	108	.37	.26495	102
.73	.45887	138	.06	.41495	128	.39	.37378	121	.72	.33507	114	.05	.29854	107	.38	.26393	102
.74	.45749	138	.07	.41366	129	.40	.37257	121	.73	.33394	113	.06	.29746	108	.39	.26291	102
.75	.45612	137	.08	.41238	128	.41	.37137	120	.74	.33280	114	.07	.29639	107	.40	.26189	102
.76	.45475	137	.09	.41109	129	.42	.37016	119	.75	.33166	114	.08	.29531	108	.41	.26088	101
.77	.45338	137	.10	.40981	128	.43	.36896	120	.76	.33053	113	.09	.29424	107	.42	.25986	102
.78	.45202	136	.11	.40853	128	.44	.36777	119	.77	.32940	113	.10	.29317	107	.43	.25885	101
.79	.45066	136	.12	.40726	127	.45	.36657	120	.78	.32827	113	.11	.29210	107	.44	.25784	101
.80	.44930	136	.13	.40599	127	.46	.36538	119	.79	.32714	113	.12	.29103	107	.45	.25683	101
.81	.44795	135	.14	.40472	127	.47	.36419	119	.80	.32602	112	.13	.28997	106	.46	.25582	101
.82	.44659	136	.15	.40346	126	.48	.36300	119	.81	.32490	112	.14	.28891	106	.47	.25481	101
.83	.44524	135	.16	.40219	127	.49	.36181	119	.82	.32378	112	.15	.28785	106	.48	.25381	100
.84	.44390	134	.17	.40093	126	.50	.36062	119	.83	.32266	112	.16	.28680	105	.49	.25280	101
.85	.44255	135	.18	.39967	126	.51	.35944	118	.84	.32155	111	.17	.28574	106	.50	.25180	100
.86	.44121	134	.19	.39842	125	.52	.35825	119	.85	.32043	112	.18	.28469	105	.51	.25080	100
.87	.43988	133	.20	.39716	126	.53	.35707	118	.86	.31932	111	.19	.28363	106	.52	.24980	100
.88	.43854	134	.21	.39591	125	.54	.35589	118	.87	.31821	111	.20	.28258	105	.53	.24880	100
.89	.43721	133	.22	.39466	125	.55	.35472	117	.88	.31710	111	.21	.28153	105	.54	.24781	99
.90	.43587	134	.23	.39341	125	56	.35354	118	.89	.31600	110	.22	.28048	105	.55	.24681	100
.91	.43454	133	.24	.39216	135	.57	.35237	117	.90	.31489	111	.23	.27944	104	.56	.24582	99
.92	.43322	132	.25	.39091	125	.58	.35121	116	.91	.31379	110	.24	.27840	104	.57	.24482	100
.93	.43190	132	.26	.38967	124	.59	.35004	117	.92	.31269	110	.25	.27735	105	.58	.24383	99
.94	.43058	132	.27	.38843	124	.60	.34888	116	.93	.31159	110	.26	.27631	104	.59	.24284	99
.95	.42926	132	.28	.38720	123	.61	.34772	116	.94	.31049	110	.27	.27527	104	.60	.24185	99
.96	.42795	131	.29	.38597	123	.62	.34656	116	.95	.30939	110	.28	.27423	104	.61	.24086	99
.97	.42664	131	.30	.38474	123	.63	.34541	115	.96	.30830	109	.29	.27319	104	.62	.23988	98
.98	.42533	131	.31	.38351	123	.64	.34425	116	.97	.30721	109	.30	.27215	104	.63	.23890	98
.99	.42402	131	.32	.38229	122	.65	.34309	116	.98	.30612	109	.31	.27112	103	.64	.23792	98
5.00	.42271	131	.33	.38106	123	.66	.34194	115	5.99	.30503	109	.32	.27008	104	.65	.23693	99
01	.42141	130	.34	.37984	122	.67	.34079	115	6.00	.30394	109	.33	.26905	103	.66	.23595	98
.02	.42011	130	.35	.37863	121	.68	.33964	115	.01	.30285	109	.34	.26802	103	.67	.23497	98
.03	.41882	129	.36	.37741	122	.69	.33849	115	.02	.30177	108	.35	.26700	102	.68	.23399	98
5.04	5.41752	130	5.37	5.37 20	121	5.70	5.33735	114	6.03	5.30069	108	6.36	5.26597	103	6.69	5.23302	97

VIII.

Illustrations of Fossil Footprints of the Valley of the Connecticut.

By JAMES DEANE, M. D.

(*Communicated to the Academy, August 8th*, 1849.)

The beautiful footprints upon the sandstone strata of Connecticut River were discovered in the year 1835. They indicate the existence of vertebrated, air-breathing, and warm-blooded animals at a remote period of the earth's geological antiquity; comprising at least two classes of the animal kingdom, *Aves* and *Reptilia*.

The number and perfection of these remarkable relics, the huge size of many of the creatures by whom they were impressed, and the consideration of the remote epoch in which they lived, invest the subject with intense interest. To myself, their study has for many years been in the highest degree attractive, and my labors in the field have invariably been compensated by successful discovery. As a result of the investigation, I respectfully offer this brief memoir. I have no intention of entering fully into the subject; my plan is merely to present some obvious practical views, grounded upon facts, leaving purely speculative conclusions out of the question. I do not even attempt a classification of the footprints. The creatures that made them existed in immense numbers, and unquestionably belonged to numerous families, genera, and species; yet to distinguish them all by strict rules of classification is absolutely impracticable. The forms of the footprints are extremely diversified, even in unblemished impressions, and glide into each other by insensible gradations. But insurmountable obstacles are presented in the various conditions of the stratum at the time the animal walked over it, and in the changes which the tracks must have, in many cases, subsequently undergone. If the surface whereon the creature trod was consolidated by desiccation, a superficial flattened impress resulted; if yet too soft, the impression must have closed in; and between these extreme conditions there are infinite modifications of form. I apprehend that another difficulty in the way of classification arises from the fact, that the footprints

were impressed by individuals in all stages of development, from the young to the perfect animal.

In many localities, as at Wethersfield in Connecticut, the footprints, being impressed upon soft and yielding clay, are ruined by subsequent changes; while at others, as at Turner's Falls, they occur without blemish. So imperfect are the footprints at most localities, that it was not until the year 1843, when my attention was attracted to those at Turner's Falls, that examples occurred sufficiently perfect to exhibit the phalangeal, ungual, and dermoid systems of the toes. Impressions which do not display these essential features are more or less imperfect. In a considerable proportion of the footprints, no doubt, the evidence is so unquestionable, that we cannot hesitate in deciding upon specific characters; yet to embrace the whole, or even the greater part of them, in any system of classification upon principles of true science, is, in my opinion, impossible. We cannot, with any thing like certainty, restore the anatomical organization of the animals by whom the footprints were impressed; and until this can be done, any system of nomenclature must be both artificial and arbitrary. The presumption is, that the animals resorted to the ancient shores for subsistence and reproduction. From the impressions of their feet we may infer that they were small or great, that they were or were not rapacious, that they were light or heavy, that they were elevated upon long or short legs, and that they were analogous to certain living types; but beyond this we can hardly go. We cannot determine their individual habits or distinctive organization, which are indispensable conditions of specific classification. I therefore neither adopt nor attempt any detailed methodical arrangement; which can, at best, be little more than an arbitrary invention, tending in no degree to advance our knowledge, but rather to involve a most simple subject in inextricable confusion. In a remote era of the earth's history, certain tribes of animals roved upon the soft margins of seas or lakes, and there imprinted their footsteps. The stratum thus impressed was subsequently overspread by a new layer of plastic clay, which was trodden upon in turn, and the impressions preserved by a newer deposit. Page after page of the vast volume of the earth's annals was thus sealed up, to be opened, after the lapse of unnumbered centuries, to our admiring eyes.

Unfortunately, no osseous remains of the animals themselves have ever been discovered. The argillaceous quality of the rock was doubtless unfavorable to their preservation; yet we might still expect that osseous *impressions* would occur. Perhaps the thin hollow shell that forms the bones of most birds, permeable by air, would cause the carcass to be floated away in the periodical overflow of the waters, supposing the birds to have perished upon the narrow shores whereon they congregated. It is only upon localities which were periodically submerged that we find footprints; it must be

here, only, that the fossil skeleton will be found. Such a discovery would supply the legitimate elements of specific distinctions. Nevertheless, we can unquestionably determine the classes to which the authors of the footprints belonged by the principles of reciprocal relation. The foot of a tridactylous bird has three phalangeal bones for the inner toe, four for the middle, and five for the outer ones; but the impression of the terminal joint is that of the nail only. Consequently, the inner toe has two, the middle three, and the outer four distinct lobate expansions, corresponding to the respective joints. Now, it is this immutable law that connects the extinct with living birds. That such impressions are due to birds is proved by a principle nearly as infallible as that supplied by osseous structure. Taken in connection with the accompanying phenomena, such as the alternation of the feet, and the impression of the ungual and tegumentary tissues, in both living and fossil races, the grounds of analogy are simple and unimpeachable.

The ancient birds were mostly tridactylous; many, however, have a fourth toe pointing backward. Some were no larger than small living birds; but in general, the impressions indicate animals vastly larger than their living representatives. Quadrupeds coexisted with the birds, and their impressions often occur upon the same stratum. These animals were diminutive, and doubtless belonged to several families of Batrachian reptiles.

The country of the extinct animals was extensive. Commencing near the northern boundary of Massachusetts, it stretches away southerly through the State into Connecticut, and reappears in New Jersey and in Pennsylvania. But the ancient sandstone basin is of limited breadth in all places. It is bounded upon either hand by primitive formations, and through the western margins of the sandstone beds a basaltic dyke has been ejected, the protrusion of which has disturbed the position of the sedimentary beds, and afforded the opportunity to investigate their contents. The localities where footprints have been observed are very numerous. In general, they are abundantly found wherever extensive explorations have been conducted in the stratified portion of the sandstone. The localities that furnish the most numerous, and beyond all comparison the most beautiful specimens, are those at Turner's Falls, the northern terminus of the sandstone beds. The models for the plates are derived from this source; whence I have obtained slabs containing as many as seventy-five impressions.

With these preliminary remarks, I proceed to illustrate these footprints by presenting copies, selected from the most perfect and beautiful examples. The drawings were put upon the stone by myself, with the utmost care, and I have attempted to compensate for the lack of artistic execution by producing faithful transcripts of the originals. I hope that my efforts in this difficult undertaking may not prove entirely unacceptable.

Plate I.

This is a miniature drawing of one of the finest specimens of fossil footprints ever obtained. I discovered it several years since at Turner's Falls; and it is now in the British Museum. It is about 8 × 6 feet in dimensions, and the drawing is reduced to one twelfth linear measure. It displays upon its surface seventy-five footprints, arranged in determinate lines. There are five rows traversing the plate from side to side, consisting of five and six tracks each. An impression from one of these rows is represented by Fig. 2, Plate IV. There is a row of fifteen impressions of a much smaller bird running upward through the left side of the plate, and a pair of them are drawn upon Plate III. Fig. 3. Another row of this variety runs across the bottom of the plate from right to left; another runs downward upon the right side; but these are imperfect, being impressed when the stratum was too soft to retain distinctly the forms: a fourth line crosses from left to right upon the upper portion of the plate. The remaining lines are impressed by a bird whose foot is drawn upon Plate IV. Fig. 1. One line of four imprints runs upward through the centre of the plate; one line of four imprints passes over the central fragment from right to left; just below is a line of two impressions passing in the same direction; and near the bottom of the plate is another row of three impressions, also passing from right to left. These several lines embrace all the footprints, and it is singular that two or more footprints nowhere fall upon the same place.

This and the next plate are given for the double purpose of representing the serial order in which the impressions to be described are arranged, and to convey a general idea of the manner in which these remarkable slabs were traversed by the ancient birds. No other specimens have ever been found of equal perfection and richness.

Plate II.

This is also a miniature drawing of a specimen of ornithic footprints belonging to the cabinet of Mr. D. Marsh, by whom it was discovered in 1848. It is accurately reduced to one twelfth linear measure; the slab is, therefore, about 10 × 6 in dimensions, and contains upon its beautiful, smooth, unbroken surface more than sixty perfect impressions. It is nearly impossible to give, by a figure or description, an adequate idea of its perfection. The configuration of the several footprints appears to be identical; the only apparent difference is that of size. In this respect it is singular; for where great numbers occur upon the same stratum, as in Plate I., the aggregate usually comprises several distinct species. The probability therefore is, that this elegant group was impressed by both young and adult individuals of the same species. The larger imprints measure ten

inches in length, and the smaller three inches; and these extremes are connected by a regular gradation of size. The stride, however, of some of the lesser imprints is nearly equal to that of the larger ones; a disparity which can only be explained upon the supposition, that the animals moved with different degrees of velocity. The two larger birds walked side by side, while others moved in all directions. Each footprint upon the plate displays the phalangeal ranks of the toes, the impression of the tarsus, and that of the nail, with astonishing fidelity. To avoid confusion, I have, as in Plate I., connected the steps comprising each individual transit with a fine line. The stride is very great in all the various lines, — a fact which indicates that the birds were tall, — and a line connecting three or more footprints is nearly direct. In short-legged birds this line is more or less oblique, which is seen to be the case in the larger footprints of Plate I.

The impressions upon this plate are identical with Fig. 4, Plate III., Figs. 3 and 4, Plate IV., Figs. 1 and 2, Plate V., and Plates VI. and VII. Nothwithstanding the disparity in point of magnitude in these several examples, I cannot doubt their identity. At any rate, it is impossible to tell wherein the difference consists, except in size. The peculiar characteristics of this class of impressions are very striking. The toes are exceedingly massive, are nearly parallel, and are always in contact, being separated in all instances by a fine ridge only. The impressions of each articulation, the heel and claws, are wonderfully distinct; and in all points this elegant and remarkable species is well represented by the footprints of existing struthious birds. I have in my possession, through the kindness of J. D. Bradley, Esq., of Brattleboro', a foot of the Emu, which sustains a perfect analogy to these impressions, — the broad, massive joints, the tarsus, and the long, blunt nails, showing an entire similarity.

The various imprints upon this plate will serve to convey an idea of the difficulties in the way of classification. If they are not considered to belong to the same species or family, I know of no distinctions whereby they may be separated. It is impossible to look upon this magnificent slab without feelings of astonishment. No language can be more eloquent or descriptive. If the creatures had walked upon plastic wax, the impressions could scarcely have been more perfect. To see consecutive tracks nearly one foot in length, made with a stride of four feet, surrounded by an assemblage of lesser impressions, is a spectacle calculated to fill the mind with sentiments of wonder and awe.

Plate III.

The footprints of six distinct species of birds are delineated upon this plate, each of the natural size. They were obtained at the various localities of Turner's Falls, and are remarkable for their distinct configuration and diminutive size.

Fig. 1 is the smallest example of ornithic footprints known. It is a left foot, and displays the marks of peculiar organization tolerably well. The toes are massive; the inner one showing two lobes distinctly, and the middle and outer ones their respective number, but indistinctly: the nails are also slightly impressed. The impression of the tarsus or distal extremity of the tarso-metatarsal bone is perceptible, and, altogether, it is the best example of this most diminutive species I have seen. The step is four inches. This species is rare, and I have seen it at no other localities.

Fig. 2 is a beautiful specimen of the left and right foot of a bird, probably no larger than the preceding; but the impression differs in this respect, that the toes are more numerous and less massive. The phalangeal ranks are not very distinct; but the general features of the track are very striking. Specimens are rare; I have only seen them at a place called the Race, at the uppermost locality of fossil footprints, four miles above Turner's Falls. This example of footprints is strictly analogous to those of several families of the existing order Passerineæ.

Fig. 6 is a fine footprint, and is very rare. It was discovered by Mr. Marsh,* an enthusiastic and successful explorer of these relics, who by his sagacity and industry has accumulated a magnificent collection of footprints. The impression is deep, and the phalangeal ranks are conspicuous. The heel is singular, being as deep as the toes, and formed of two equal oval parts, each pointing obliquely outward. The first joint of the middle toe is prolonged backward to an extent so unusual as to suggest the probability of distortion. It may be remarked in this place, that the inner and outer toes in fossil examples project backward to a like extent nearly; but the outer or long one invariably a little the most. It is well to bear this fact in mind; for the outer toe, in good examples, Fig. 4, for instance, appears to project much farther backward than the inner one. This apparent difference is caused by the impression of the bilobed tarsus, one division of which is placed in continuation of the long toe, and the other falls between the first joints of the lateral toes, by the embrace of which it is in many species much modified in form. Such, however, does not happen in Fig. 3, for instance. Fig. 6 is so rare, that neither Mr. Marsh nor myself have seen it in consecutive series; but the length of the step was probably four or five inches. The bird was comparatively heavy. It will be noticed that the imprint of the nails is much distorted, which results from subsequent changes in the soft material upon which the impression is made.

Fig. 5 is drawn from a cast presented to me some years since by President Hitchcock, as was also Fig. 1, by whom both species were discovered. It is a fine, deep, regu-

* Wherever the discovery is not directly accredited to others, it has invariably been made by myself.

lar, but imperfect impression, showing neither phalangeal ranks or nails. It has the fourth toe pointing backward, as in many orders of existing birds. The rolling up of the mud anterior to the lateral toes, and a prolonged depression posterior to the heel, suggests the idea of the slipping of the foot, which often happens. The clearness and symmetry of the impress renders it very elegant; still it is but an outline impression.

Fig. 3 is a beautiful example of footprints, perfectly developed in all respects. The order of articulations, and the imprint of the tarsus and nails, are clear and unequivocal. This variety is common at Turner's Falls, but is seen at no other locality. It is shown in consecutive series upon Plate I., which contains several examples. The line of fifteen impressions, running upward through the whole length of the plate, belongs to this species. That running transversely across the upper half from left to right is another; and there is still another at the bottom of the plate, crossing from right to left. The impress is usually superficial, but always accurate. The position of the footprints *a* and *b* would seem to be irregular, but it must be remarked that the feet of birds almost invariably point inward. In reptilian quadrupeds the reverse happens, their feet uniformly pointing outward; and this is an important distinction in studying these fossils. The central toe in birds usually points to the succeeding footstep. The direction, therefore, in which Fig. 3 moves is not perpendicular to the plate, but obliquely to the right. To know where the repetition of *a* will happen, take the distance *a* and *b*, and the direction of the central toe *b*, and the proper place will be accurately given. The original slab of Plate I. was incrusted by a thin layer of micaceous sandstone, the removal of which required the laborious application of the chisel; yet so accurate was the principle, that I uncovered row after row, cutting down at once upon the footsteps only. A line, therefore, connecting these impressions runs alternately from side to side, and its obliquity depends upon the length of the leg. Thus, in Fig. 3, the zigzag direction of this line is considerable, as will be seen by reference to Plate I., while the impressions in Plate II. are almost in a direct line.

The distinctive features of this species, then, consist in the strongly marked and tapering toes, long and blunt nails, the divergence of the lateral toes, and the broad space which separates them from the central one and the tarsus, which is separated from the toes, and is placed farther backward than usual. The lateral toes with the double-headed tarsus represent the letter V correctly.

Fig. 4 is a beautiful footprint, and is the type of a series of impressions to which I shall bespeak particular attention. It belongs to that group represented by Plate II. Its peculiarity consists in its massive toes, its long and narrow impression, its graceful outline, the perfect impression of the tarsus and nails, and its great length of stride. The

divergence of the toes is so slight that they are in contact. There is a peculiarity in the long toe which I shall show in other examples, namely, there appear to be but three joints, yet it really has the requisite number; the third and fourth joints being so compressed as to form a single impression. The nails are strong and blunt, the tarsus deep and apparently joined to the outer toe, and, on the whole, the foot is analogous to that of struthioid birds. It may be noticed that the second and third joints of the central toe brushed the stratum a little distance to the right, before the foot settled permanently. As I shall have occasion again to refer to this beautiful example, I will now only say that the stride is ten inches.

Plate IV.

The footprints upon this plate represent three distinct species of birds, and, from their magnitude and perfect impress, they are peculiarly adapted to illustrate the organic configuration of the foot. The originals were derived from Turner's Falls.

Fig. 2 is the right foot of a short-legged, heavy bird, as is known by the shortness of stride, which is fourteen inches, from the depth of the impression, and the breadth to which the feet are separated. It is common at Turner's Falls, and a few other localities, and is nearly always perfect. It is represented in consecutive series upon Plate I., the lines of large impressions running from side to side representing this species. Fig. 2 is taken from a footstep in one of these lines. The toes are very massive, distinctly separated, and the ungual appendages perfectly defined. The surface of the slab is not rough, nor yet smooth, yet the weight of the bird condensed the resisting medium to the smoothness of glass. The outer toe is relatively long and tapering, and the whole number shows the lobate divisions beautifully. In this instance, the tarsus did not descend low enough to make a distinct impression, which is usually the case in this species. The nails are blunt, long, and broad. Altogether, it is a most remarkable impression; but beyond the legitimate inference that it is referable to a heavy bird with short legs, all is hypothetical.

Connected with this species are the usual embarrassing questions concerning specific distinctions. It is the representative of a large group of similar impressions, and is the largest of the series. But, gradually descending in magnitude and extent of stride, are many impressions that sustain a close affinity to it, and the question whether they should be regarded as specifically different, or as being due to younger individuals, is difficult to decide. If all the modifications of the fossil footprints were regarded as specific, the list of species would indeed be very great.

Fig 1. A right foot, in the general appearance analogous to Fig. 2, except that it is

smaller and not quite so perfect. The impress is deep and clear, the outer toe is long and tapering, and all the toes exhibit the articulating ranks. The impress of the middle and inner toes is slightly distorted, yet the appearance of the fossil is expressive. The tarsus is slightly impressed. From its analogy to Fig. 2, it might be supposed to be the young of that species; which cannot be the case, for the stride is invariably very long. In this instance it is twenty-two inches. The line of four impressions, running upward through the centre of Plate I., was impressed by this species.

Figs. 3 and 4. These drawings represent a magnificent species of footprint, which I have selected to illustrate the probability, that certain analogous impressions, differing in magnitude, are due to an identical species, being impressed by individuals in various stages of development. The distinctive marks of organization are very striking. The foot is long, narrow, and distinctly impressed. A peculiar mark of distinction in this species is the shortness of the outer toe, projecting backward and forward little more than the inner toe. In Figs. 1 and 2, the outer toe is relatively very long; in this species. it is relatively very short. Another remarkable distinction is the circumstance, that the lateral toes embrace and modify the form of the first joint of the central toe. The lateral toes diverge less than in other species. The tarsus is invariably impressed, and its lobes and those of the respective joints are exceedingly massive. The nails are perfectly defined. Those terminating the lateral toes have an unusual divergence. The step is very long, in the figures being about two feet. The bird was doubtless of great relative magnitude, for the impress, like that of Fig. 2, is always perfect, a circumstance resulting from condensation by great pressure. The concavities of the joints are smooth, polished, and lustrous. These large and powerful birds appear to have outlived other species, for while they became extinct, or at least disappear, these are found under all circumstances. They abound at Turner's Falls, where the strata rest upon a base of igneous rock, and also at the Race, several miles distant, and at intermediate places. Figs. 3 and 4 are represented upon Plate II. in consecutive order. If the reader will turn to Fig. 4, Plate III., he will see that it bears unimpeachable analogy to the figures under consideration, and a regular gradation in point of size connects them, extending to impressions of more than one foot in length, (I have seen them of eighteen inches,) with a stride of four feet.

Plate V.

The footsteps upon this plate are, I think, identical with those of Fig. 4, Plate III.: Figs. 3 and 4, Plate IV., being impressed by larger individuals, upon strata of different degrees of resistance. Fig. 1 is deep, while Fig. 2 is a very superficial impression. In

Fig. 1, the clay upon which the bird trod was yielding, yet not too soft to retain the form of the foot perfectly. The tarsus, phalanges, and nails are distinct. In Fig. 2, the impress is flattened by the resistance of the stratum to the weight of the bird; still, the articulations are distinct. The stratum is covered with the marks of rain-drops, but the weight of the bird obliterated them completely. I have often seen, in long rows of footprints, the phenomena presented by these two figures. The first impressions of the series would be flattened, the succeeding ones deeper, and *vice versâ*, the animal passing from one condition of the strata to the other, or from the higher parts of the shore into the water, or in the opposite direction. Fig. 2 is spread more than Fig. 1; but the difference is attributable to the different degrees of solidification of the strata. The most elegant examples of footprints are often those which are completely flattened, for they usually present a clearer definition than those which are deep.

Plate VI.

The figure represented by this drawing is the middle toe of a footprint, fifteen inches in length, and ten in breadth between the extremities of the lateral toes. The stupendous magnitude of the extinct birds, as indicated by this fine impression, is without parallel in existing types. The area of the foot is at least four times greater than that of any living bird, and doubtless the true proportions were still more extraordinary. Colossal birds abounded in vast numbers during the sandstone era, for their vestiges are distributed over the entire extent of the sandstone basin. They are most numerous at Turner's and at South Hadley Falls.

The phalangeal divisions of this immense footprint are perfectly defined; and between it and Fig. 1, Plate III., there occurs, in the ornithic footprints of Connecticut River, a regular gradation of intermediate forms. I obtained this footprint from Turner's Falls.

Plate VII.

Aside from its vast size, this is a beautiful and exceedingly interesting footprint, on account of the distinct impression of the heel, phalanges, and nails. The figure is taken from the specimen of Mr. Marsh, which is represented on Plate II. It holds an intermediate grade between the figures of Plates V. and VI.; and they were all, in my opinion, impressed by different individuals of the same species of bird, in various stages of growth. The remarks upon Figs. 3 and 4, Plate IV., are applicable in this instance.

Plate VIII.

The footprints upon this plate embrace three distinct species of quadrupeds from the

quarries at Turner's Falls. They indicate animals of diminutive forms. Their peculiarity consists in the great disproportion between the hind and fore feet, in which respect they resemble some existing batrachian reptiles, lizards, salamanders, &c.

Fig. 1 was discovered by Mr. Marsh, whose cabinet contains a fine collection of this class of fossils. Figs. *a*, *b*, and *c* are consecutive impressions. The distinctive character of this species consists in each foot having four tapering, radiating toes, and in a prolonged depression backward of the tarsal bone. The fore foot is planted in advance, and a little *outward* of the hind foot, while in Fig. 2 the fore foot falls *within* the impress of the posterior member, and in Plate IX., Fig. 1, it is directly in advance. These impressions are so perfect as to show marks of the sharp claws terminating the toes. In the short stride it differs from

Fig. 2, the stride of which is nearly twice as great, although the foot is smaller. Another distinction consists in the form of the toes, which are massive, broad, and blunt, and lie in contact. I may remark here, that the position of both *a* and *b*, Fig. 2, is erroneous. Fig. 2, *a*, should point obliquely to the *left*, precisely like Fig. 4; and Fig. 2, *b*, should also be reversed. The mistake was caused in transferring the outline, and was not discovered in time to be corrected. The impressions are remarkably fine, and are derived from Mr. Marsh's museum, although I discovered this species several years ago. The fore foot is usually placed *within* the hind one; in Fig. 2, *a*, the small foot is partially obliterated by the impress of the hind one. Unlike Fig. 1, there is no prolonged depression backward from the foot; but, in place of it, the tarsal impress is perfect. There are four toes; the two outer ones of equal length nearly; the two inner ones are shorter. A line connecting *a*, *b*, *c*, Fig. 1, is abrupt; that connecting Fig. 2 is nearly direct. The animal, therefore, had very long legs, which the stride also indicates, and small feet, with exceedingly thick toes. I have seen rows of ten consecutive impressions.

Fig. 4 is strictly identical, although much larger than Fig. 2, and between them there occurs a regular gradation of size.

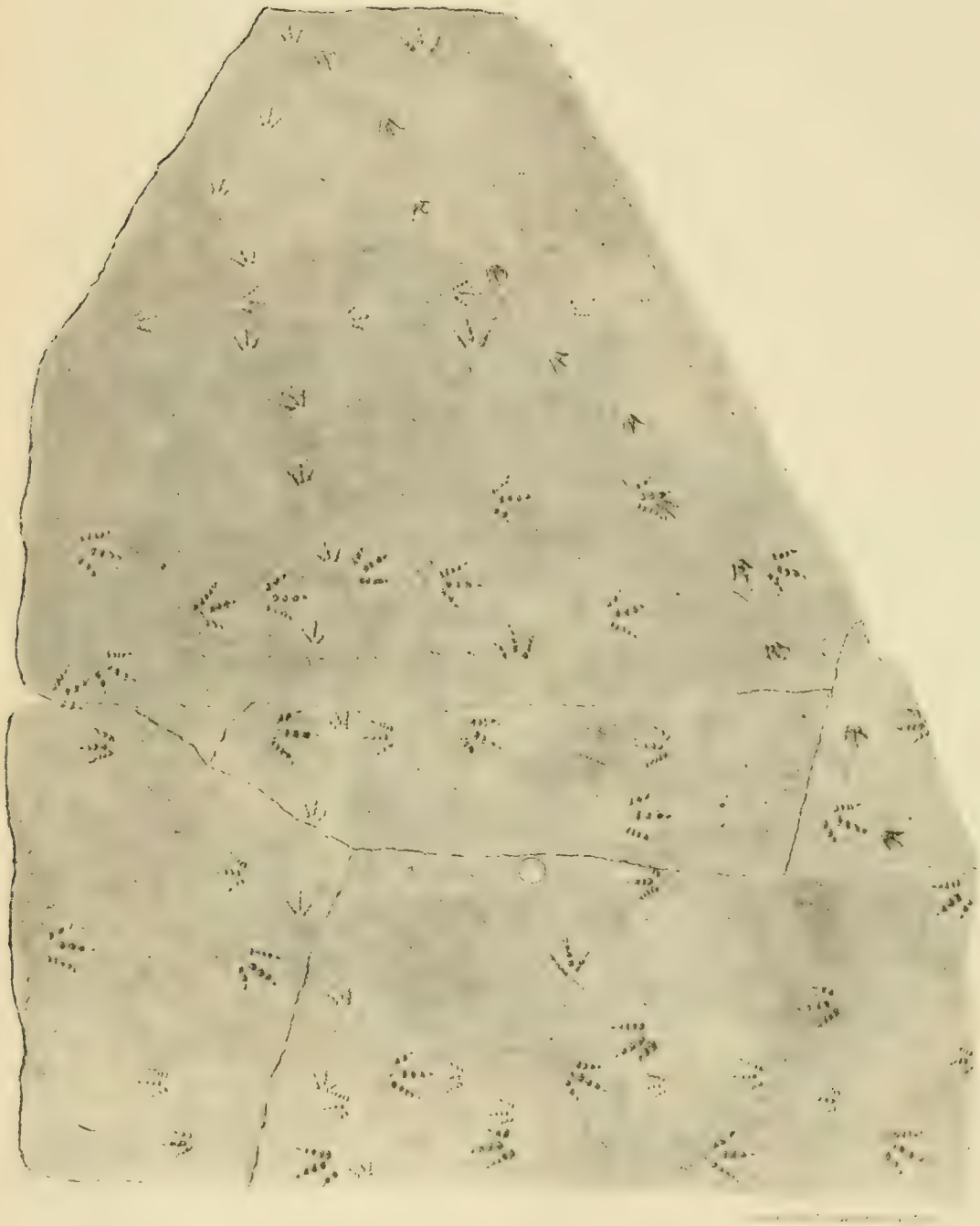
Fig. 3 is a remarkable example of quadrupedal imprints, and one which is difficult to understand; for, unlike the preceding figures, the impress of the fore foot appears to be wanting. It is taken from a series of seven pairs of deep impressions. Each foot has four toes pointing obliquely outward, and, unless upon the supposition that the impress of the fore foot was too slight to be retained, I cannot comprehend the movement by which the animal advanced. Mr. Marsh has a larger specimen, apparently identical, in which the same difficulty exists. In both instances, the footprint is deep and imperfect, showing that considerable change happened to the stratum subsequent to its impress; and this might suffice to obliterate a slight impression of the fore foot.

Plate IX.

The footprints upon this plate belong to the same class as those upon Plate VIII., and in general appearance there is a striking similarity, yet they are specifically distinct. They were discovered by Mr. Marsh, at Turner's Falls, and are deposited in his cabinet.

Fig. 1 has a strong affinity to Fig. 1, Plate VIII. It has the like number of toes, but their arrangement is entirely different. It has the posterior ulnar impress, in which respect there is no resemblance. Three of the toes point forward; they are long and slender, the outer one diverging considerably. The fourth toe is inserted far behind the others, and is short and pointed. The posterior depression is irregular, concave, and terminates in a deep, rounded impress, while in Fig. 1, Plate VIII., this appendage is longer, broad, and becomes superficial behind, until it disappears altogether. In Fig. 1, Plate VIII., the feet point obliquely outward; in this, obliquely inward, which is the first instance of the kind I have seen in quadrupedal imprints. The fore foot is placed directly in advance of the hind one; while in Fig. 1, Plate VIII., it is planted forward and outward; and in Fig. 2, Plate VIII., directly inward. These are unquestionably specific points of difference.

Fig. 2 represents a singular species of quadrupedal footprints, of peculiarly diminutive size; being the smallest impressions of animals ever discovered. The style of the foot is analogous to Fig. 3, Plate VIII.; that is, there is no evidence of a fore foot. Unlike it, however, the toes are long, slender, parallel, and extremely delicate. The surface of the stone is exceedingly smooth, giving great distinctness to the impressions, notwithstanding their minuteness. The delicate impress of the extremities of the toes in dragging from one step to another is well marked. How strange that a creature so insignificant should leave such clear and indelible vestiges, enduring for countless cycles of time, while the proudest efforts of intellectual man scarce survive him, and a few centuries obliterate his name, his language, and his works for ever!



FOSSIL FOOTPRINTS OF BIRDS.

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FOSSIL FOOTPRINTS OF BIRDS.

Fig 1

b

Fig 4

Fig 2

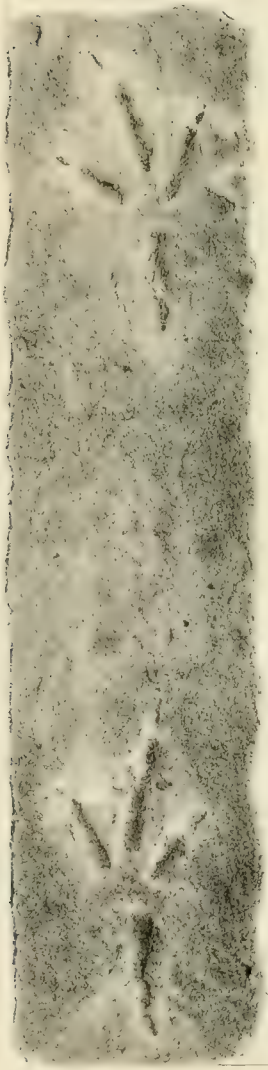

Fig 3

Fig 5

a

Fig 6

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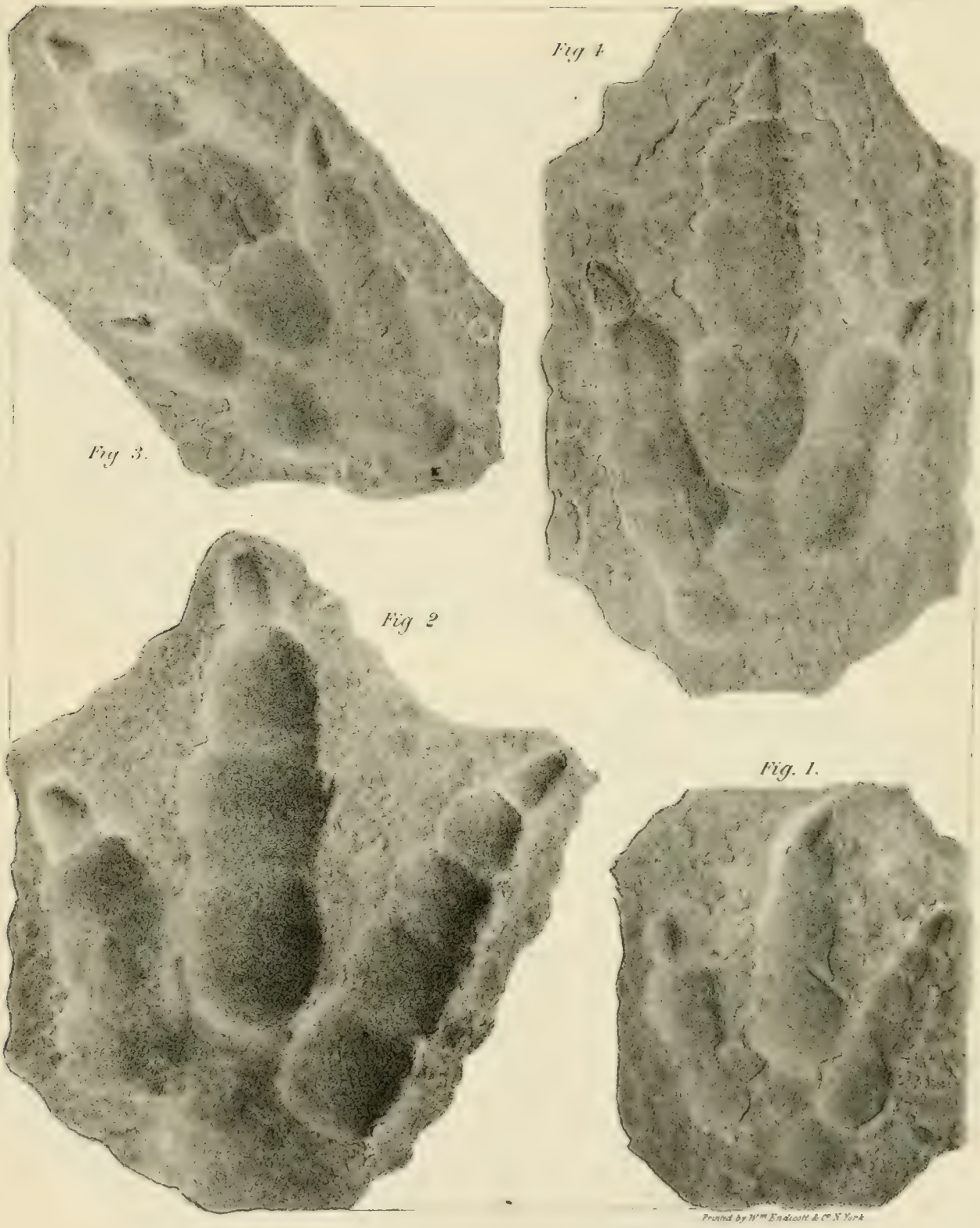

Fig 4

Fig 3.

Fig 2

Fig. 1.

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FOSSIL FOOTPRINTS OF BIRDS.

Fig. 1

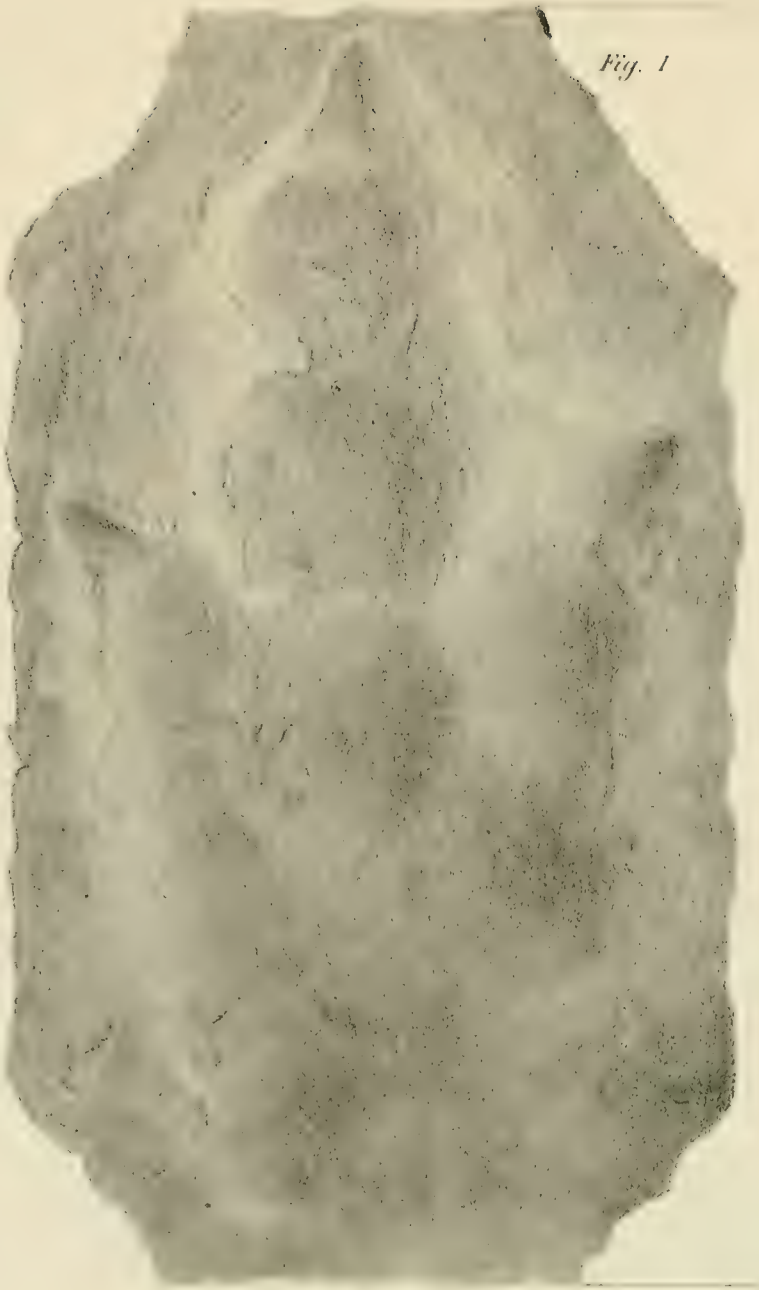
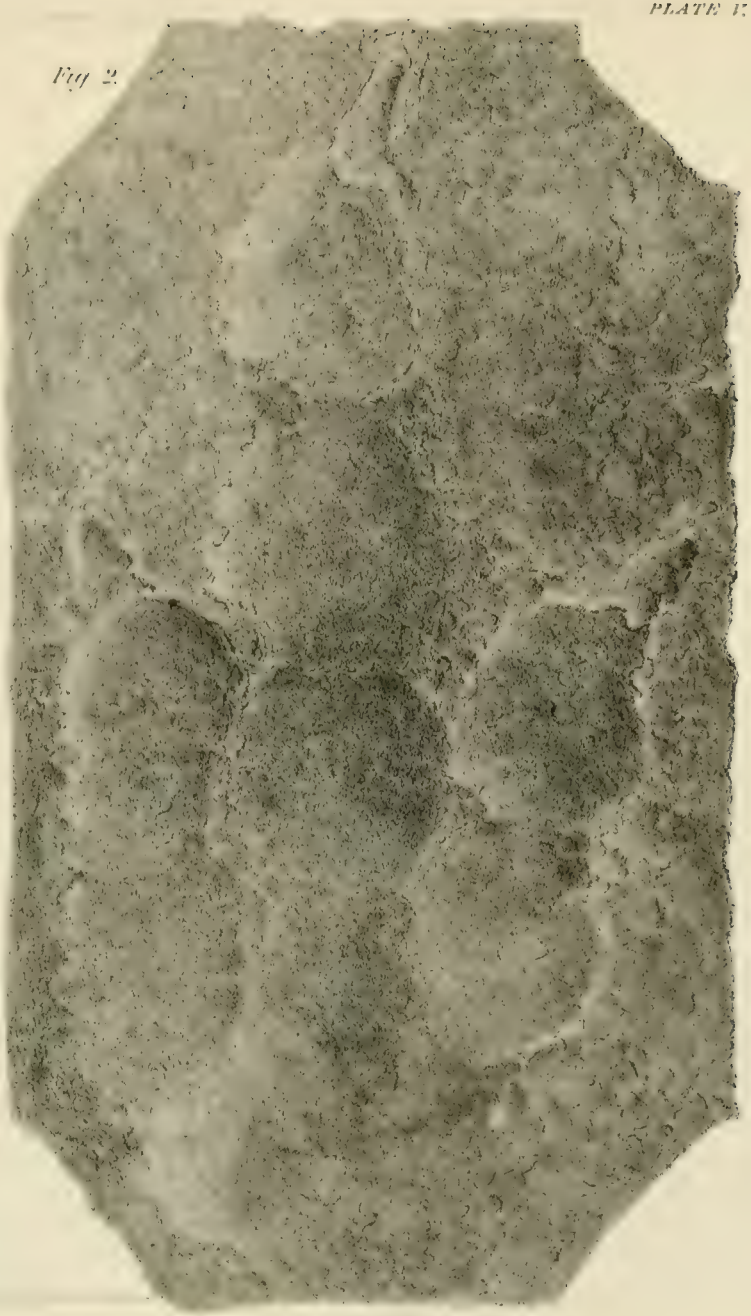


Fig. 2.



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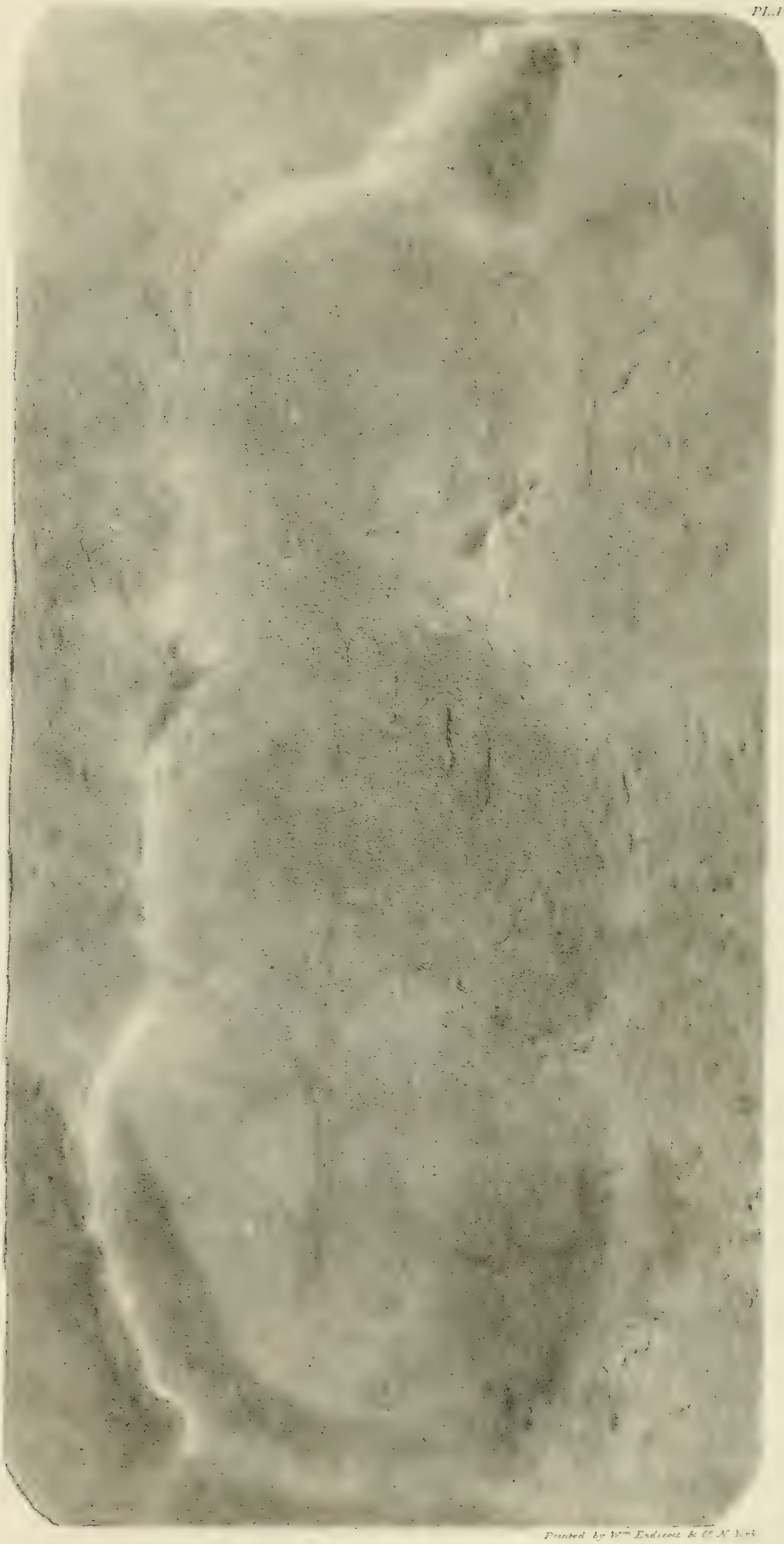
FOSSIL FOOTPRINTS OF BIRDS.



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FOSSIL FOOTPRINTS OF BIRDS.

FOSSIL FOOTPRINTS OF BIRDS.

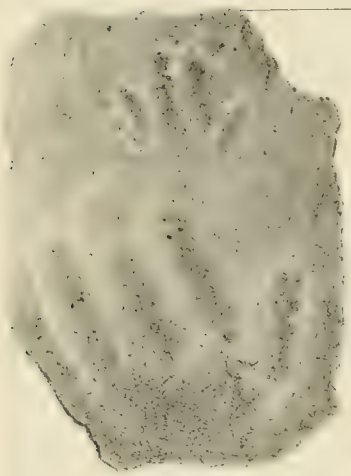


Fig. 4

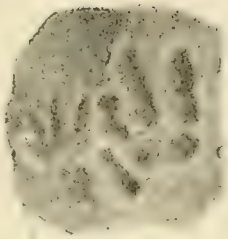
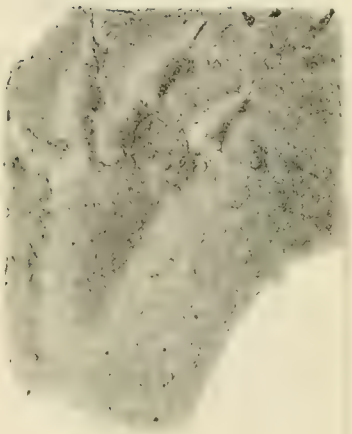


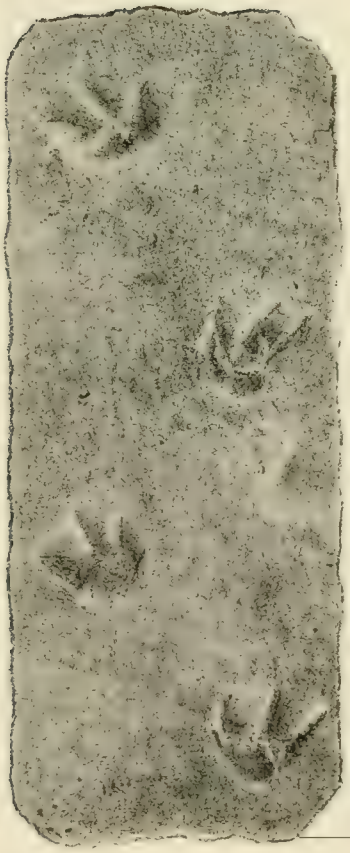
Fig 2 b



c

b Fig 1

Fig 3



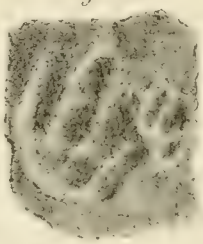


Fig 2 a

a

FOSSIL FOOTPRINTS OF QUADRUPEDS

Fig. 2

b.

c

Fig. 1

a

FOSSIL FOOTPRINTS OF QUADRUPEDS.

MEMOIRS

OF THE

AMERICAN ACADEMY

OF

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NEW SERIES.

VOL. IV.—PART II.

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IX.

Contributions to the Natural History of the Acalephæ *of North America.*

By L. AGASSIZ.

PART I. — *On the Naked-eyed Medusæ of the Shores of Massachusetts, in their Perfect State of Development.*

(*Communicated to the Academy, May 8th and May 29th*, 1849.)

There is a deep scientific interest connected with the study of Medusæ. Notwithstanding their slight consistency and their extraordinary transparency, a highly organized structure has been observed in many of them; and, though the most opposite opinions still prevail among observers respecting the signification of the facts thus ascertained, it is not the less evident that their structure deserves to fix the attention of physiologists in the highest degree. It is, in reality, one of the most wonderful sights which the philosophic naturalist can behold, to see animals scarcely more dense than the water in which they play, and almost as limpid, perform in that medium movements as varied as those of the eagle which soars in the air, or of the butterfly dancing from flower to flower, testifying by their activity their sensitiveness and their volition. Their mode of living, as far as it is known; their periodical appearance, like annual or biennial plants; their rapid growth; the short duration of their life; the brightness or softness of the light which they emit during night, and which illuminates even the deep ocean; the wonderful facts which have been ascertained respecting their mode of reproduction; — all this is of a character to strike, in the highest degree, the curiosity even of the most careless. It is, therefore, not surprising, that, from time immemorial, the phosphorescence of the sea, which is, in a great measure, owing to the presence of jelly-fishes, should have excited the deepest interest, and that, of late, the natural history of Medusæ should have become one of the most fascinating subjects for the ablest scientific observers, and opportunities to trace and repeat their researches, a matter of the most ardent desire on the part of inland naturalists, whose curiosity has been excited to the utmost by the narrative of so many wonders.

A new-comer into the field of these researches, after having spent the best of my earlier years in other labors, and happy to find still something to glean where Péron and Lesueur, Cuvier, Eschscholtz, Ehrenberg, Milne-Edwards, Mertens, Brandt, Lesson, Sars, Loren, Steenstrup, Von Siebold, Dujardin, Will, Edward Forbes, Sir John Dalyell, and others, have reaped full harvests, I have not the pretension to offer any thing very complete upon this subject.

Three years of study on the sea-borders have hardly yet fully opened my eyes to its inexhaustible treasures. I bring only some loose fragments respecting several points of the structure of Medusæ, before unknown or little understood, which I have attempted to clear up, as far as it has been in my power.

In the illustration of the objects which I am about to describe, I have been largely assisted by the ability of Mr. Sonrel, whose quickness in seizing the characteristic features of organized beings, and in reproducing them with a delicate touch, I have already had opportunities to appreciate, during the publication of my researches upon the fossil fishes, and those of the fresh waters of Europe, and also upon the Echinodermata and shells. All the illustrations of Medusæ which I now publish are drawn, as well as engraved, by his hand. The part which he has taken in this work is so important, that, I am happy to acknowledge, without his aid, I should have been unable to reproduce, or, at least, to make equally intelligible to others, the facts which I had ascertained.

Some of the numerous figures which I have caused to be engraved may appear rather superfluous. But it must be considered that these animals are so perishable, that it will hardly ever be possible to preserve extensive series of them in our museums, or to procure of those capable of preservation a sufficient number to represent them in their different attitudes and under various circumstances, so as fully to illustrate all the details of their structure. For, though entire specimens of the smaller species may be preserved in Goadby's liquid with tolerable success, yet details which may be traced in the fresh state are almost always lost soon after. Moreover, they have to be traced under rather high magnifying powers, and for some details the highest powers at our command are hardly sufficient for the investigation. It must be obvious, therefore, that full original illustrations of as many of these animals as can be obtained will be always of service to the progress of science, and should at once be secured whenever the opportunity offers of investigating the new forms which fall within our reach; especially when we consider that, in many cases, opportunities may not be afforded for years again to investigate the same subject in the same state.

I should mention, also, some advantages I have derived from availing myself of various methods of proceeding in studying these animals. While many details of structure can

be made out only from living or perfectly fresh specimens, there are others which may be best observed in those which have been for some time dead. We should, therefore, be in no hurry to place living Medusæ under the microscope; or to take them out of the water to observe them more closely. We may first watch their movements, and trace, as far as possible, in the complete specimen, the connection of parts, and the influence which the movements have upon the circulation of fluids, and upon the changes of form of the whole body. We may next proceed to the investigation of those external details which are best traced upon fresh specimens, such as the microscopic structure of the tentacles, the fringes of the mouth, the eye-specks, by cutting such parts from living specimens, which will survive for some time after this operation. But we should carefully preserve the dying and dead bodies, and closely watch the process of decomposition; for, during the cadaveric stiffening of the animal, tissues may be discovered which remain unnoticed in the living or fresh animal. Such is particularly the case with the muscular, or rather contractile, system of cells by which the voluntary movements are effected, and which are best seen when strongly contracted. Of course, the forms exhibited in the contracted state are neither natural nor frequently observed during life, as they only exemplify the action of the contractile tissue in its utmost state of contraction. But if we do not obtain in that way a satisfactory view of the object, we, at least, learn where to look in order to study these parts in a more natural condition, and gradually to discern them where their existence was unsuspected before. Even fragments in a decayed state should not be neglected, as the manner in which the parts separate during decomposition affords the means of ascertaining the limits of the different tissues; some decomposing more readily than others, under the same circumstances. For instance, the easiest way to study the epidermis, or simple layer of epithelial cells, which cover the whole surface of the body of Medusæ, is to allow decay to commence without disturbing them; when it will be easy, after a certain time, to take off a thin, continuous layer of the most beautiful polygonal, nucleated cells, forming a single layer over the whole surface.

The most active species, when it is desirable to study them alive, can easily be brought to a state of immobility by ether or chloroform. I have frequently seen even the smallest species, such as Hippocrene, recover from a state of perfect immobility and insensibility to active life again. Even had I not succeeded in finding distinct sensitive apparatus, I should, from this very fact, have been led to claim for them the power of feeling, so plainly shown by such experiments.

Another method of studying these animals, used frequently to great advantage, has been, to drop them into liquids of various densities, — into fresh water, for instance, or into

alcohol, or various saline solutions; when the differences of shade introduced in the tissues of different kinds has often proved a useful means of ascertaining structural details otherwise indistinct, or altogether undiscovered. All these different modes of investigation have been repeatedly tried under various circumstances.

I may be allowed to mention, also, that I have used, with great advantage, Goadby's liquid for the preservation of Medusæ, with all the care and precautions indicated by Professor Edward Forbes, in his admirable *Monograph of the British Naked-eyed Medusæ*. It is important that every one who repeats these investigations should be fully assured that his success in preserving good specimens will depend altogether upon the care he takes in using successively the liquids of different density, and also in changing regularly and frequently the liquid in which the specimens are immersed, until they are fairly saturated and the process of endosmosis has ceased to go on. I have lost most valuable specimens from having trusted too soon to the preserving power of the liquid in its first applications.

SARSIA.

In the year 1835, Sars published, under the name of Oceania tubulosa, a description, with figures, of a small Medusa discovered by him on the shores of Norway. It is found in that most remarkable little volume of his "Descriptions,"* which contains the germs of so many important developments in our knowledge of the lower animals. This species was afterwards taken as the type of a new genus by Lesson, who, in his work on Acalephæ,† describes it under the name of Sarsia tubulosa. Since that time, a few species have been added to those mentioned by Lesson.

It would seem as if the genus Sarsia was now fairly established, as it rests upon well-defined and easily ascertained characters; but since it has been discovered that Sarsia is only one condition of development of animals which differ widely at other periods of the year, it now remains for us to ascertain under what generic name it should finally stand in our system. For the common Coryna or Syncoryna represents one of their stages of growth, and the Oceania or Sarsia is another. And it must have been a high satisfaction to Sars, who first discovered the species, and introduced it to the notice of naturalists, to have also been the first to perceive that these little Medusæ are developed from a polyp-like stem, which alternates in their generations with the free Medusæ.‡

* *Beskrivelser af Polypernes*, &c. Bergen, 1835. 4to.

† *Histoire Naturelle des Zoophytes. Acalèphes.* Paris, 1843. 8vo.

‡ *Fauna Littoralis Norvegiæ.* Christiania, 1846. fol.

The existence of this type on the American shores was first mentioned by Dr. Gould, in his Report on the Invertebrate Animals of Massachusetts, in which Oceania tubulosa of Sars is enumerated among the animals occurring along these shores. They were among the earlier Medusæ I saw on this continent, Dr. Gould himself having kindly showed me the localities where he procured them. Since that time, early in the spring of 1847, I have also obtained, by dredging, specimens of the Coryna of Boston Bay, from which the perfect Medusa is derived.

We have here a double question to settle, — first, whether the European species is identical with that of North America, and, next, under what generic name this species should finally stand in our system. This is a matter of no slight importance, now that the zoölogical nomenclature can no longer be viewed in the same light as formerly. The knowledge of alternations of generations of animals of most heterogeneous forms, belonging to the same specific types, calls for a precise understanding about their systematic names. As the question has not yet been discussed, I shall, I trust, be allowed to say a few words upon it, although it is not my intention to describe on this occasion what I know of the metamorphoses of this animal, but only to allude to its structure, reserving my account of the embryology of Medusæ for another paper.

Reviewing all the facts which have been brought to light on these points, and availing myself of my own investigations, I have shown, in my Lectures on Comparative Embryology,* that Hydroid Polypi are not simply a lower form of stemmed animals, producing at a given period more highly organized Medusæ, but that they are themselves, by their structure, real Medusæ, differing from the free forms with which they alternate mainly in their being attached by a stem, and much less in their real structure than was perhaps supposed at the time when the so-called Hydroid Polypi were still considered as members of the class of Polypi. If I am right in this respect, — if Sarsia and other naked-eyed Medusæ can no longer be considered as the productions of animals belonging to another class, — if we have really to remove the so-called Hydroid Polypi to the Medusæ proper, and simply to view them as alternate generations of these Medusæ, or as different modes of existence of animals of one and the same species, — then there can be no doubt of the propriety of describing all these phases of their development and alternate generation under one and the same generic name; by which method we shall at once

* *Twelve Lectures on Comparative Embryology*, delivered before the Lowell Institute, December and January, 1848–49. Boston, 1849. 8vo. — See also a paper read before the American Association for the Advancement of Science, held at Cambridge in August, 1849, entitled, *On the Plan of Structure and Homologies of Radiated Animals*, with reference to the systematic position of the so-called Hydroid Polypi.

get rid of the perplexity which attends the study of their complicated history, narrated as it is under so different heads. Even at present, and with all the information we already possess upon alternate generations, I find it most difficult to impress naturalists, who have devoted more attention to other branches of natural history, with the true view of this subject. No doubt, the difficulty arises from the circumstance, that, in most cases throughout the animal kingdom, all the individuals of the same species are so much alike through their whole life, as to be easily combined in one comprehensive diagnosis under a common generic and specific name. But whenever there are sexual distinctions between individuals of the same species, we begin to meet with difficulties, as there is a fatal propensity among observers to force their views upon nature, and to take this or that form as most characteristic, and to mould the description accordingly, now making the male, now the female, the type of the species; describing almost as mere occasional differences those constant and permanent peculiarities which characterize all female individuals, or *vice versâ*, as if, in different classes, males or females were more prominent in their appearance: as if it were not more correct and more in accordance with nature to mention at once, that in such species males and females differ widely, the males being distinguished by such and such characters, and the females by others, adding, if necessary, a similar description of the young.

Among animals which undergo extensive metamorphoses, the method of describing formerly employed has become altogether useless. No philosophical observer will, in future, be satisfied with a mere diagnosis of the winged state of a butterfly or a moth, when he knows how characteristic, how peculiar, and how interesting the earlier stages of growth of these animals are. I must confess that it gives to me personally as much satisfaction to watch a caterpillar, to study its anatomical and physiological characters, and investigate its zoölogical forms and peculiarities, to describe these details and compare them with similar features observed in others, as I experience in investigating in the same way either the chrysalis, or the perfect insect, or even the egg from which the whole was derived. It is a great mistake to withhold the information acquired upon these different points from our works on comparative anatomy, and to consider embryology almost as a science by itself, unconnected with zoölogy and comparative anatomy. Though the importance of such combined studies is gradually felt more and more, the best evidence I would adduce to show how little such views even now influence the progress of our science will be seen by referring to our best and most recent text-books, both in zoölogy and comparative anatomy.

But just as zoölogists have aimed always to refer their observations upon the different stages of growth of an individual species to the same systematic name, giving the ap-

pellation of Silk-worm, for instance, to that animal even in its chrysalis and moth condition, because it is best known in the form of the silk-producing worm under that name, so should we now adopt one single systematic appellation for all the phases of growth of those animals which undergo alternate generations, of course adopting as that which is to be preserved the oldest name under which the animal was first noticed, whether in its free condition or in the fixed state of its earlier metamorphosis.

I am well aware, that many inconveniences will arise from such a practice; and that names with which we are most familiar will have to give place to others less generally in use; but there is no safety in nomenclature without absolute adherence to the law of priority. Just as we discard for ever the recent appellations of so many young animals which have been of late considered as peculiar types, because we recognize them as mere embryonic conditions of well-known animals, so should we select the older name whenever we find that the adult male and the female of an animal, or the young and the adult state, have been described as two distinct species. We preserve the name of Larus marinus because it is the older, not because it is the more appropriate, of the different names under which the various plumages of our large marine gull have been described.

There can be no hesitation in the present case. The stemmed and fixed generation of our Medusa had been known and named long before its free Medusa form was ascertained. We shall therefore unhesitatingly discard in time the generic name of Sarsia, though no one is more desirous than I am to see the name of Sars proclaimed as one of those who have contributed a large share to the advancement of our science. There is, however, a difficulty in introducing at once a change in this case, since the Corynæ have been subdivided into so many genera of late, as to render it almost impossible to decide which of them should be preserved and to which all the different species now known belong. The difficulty is further increased by the claims which Dr. G. Johnston has recently raised in favor of some older names which had been disregarded by modern writers.

I would also urge the necessity of a detailed description equally complete of the various phases of life of these animals, and would propose to introduce these details under distinct heads so far as to preface the descriptions by the designations of *Proles polypoidea* and *Proles medusina*.

It is a matter of great difficulty to ascertain the specific identity or difference between animals of this class, and, I must confess, I could hardly venture to decide, in the present case, whether Sarsia tubulosa of the British coast, and those specimens which Dr. Gould has identified with the European, be truly identical or specifically distinct. There are nearly as many reasons to be given in favor of their identity as for their specific difference,

and a direct comparison has not yet been possible. But if, in the perfect state, the differences are less obvious, (though, to me, they seem striking enough to justify the specific distinction,) there is such abundant evidence obtained by a comparison of the polypoid generation, in which the tentacles and ovarian bunches, as well as the form and ramifications of the stem, are so different, as to leave no doubt of the specific distinction between the European and North American Corynæ. However different or similar these species may therefore appear to different observers, so much is plain from what we know at present about them, that they are close representatives of each other in the two continents, and that, whether viewed as distinct species or as climatic varieties of the same species, we have to acknowledge in them either those limits of variations which occur between climatic varieties of the same species, or that degree of close affinity which we recognize in specific representatives of the same types in analogous climates.

Having satisfied myself of the specific distinction of the European and North American species alluded to above, I shall designate the American under the name of Sarsia mirabilis, intending to express by that specific name both the wonderful changes which this species undergoes in its metamorphoses, and my admiration of the keen observer who led the way in these investigations, and whose name I should have been most anxious to retain as the generic appellation of this type, were it not contrary to the most desirable improvement of our nomenclature.

Sarsia mirabilis in its polypoid form occurs at the bottom of Boston Harbour, and is never seen exposed, even at low water. I have obtained it only by dredging. In its Medusa form it begins to be freed early in spring, and is very abundant along the wharves all round Boston Harbour. When first freed from its polyp-like stem, the bell-shaped body is about one fourth of the size to which it grows before it has again matured its eggs; when it dies, after laying them, towards the middle of summer.

There is something quite peculiar about the duration of life of these animals, and its disappearance at that particular season of the year. This connection of the animals with the order and succession of the seasons is in itself very striking, and is particularly evinced in the lower animals, in which the duration of life itself is dependent upon the duration of the year and its changes, while in higher animals certain phenomena of life recur regularly at given periods, though their longevity seems to be more and more independent of the duration of the year and the influence of the season as they belong to higher and higher types. In Medusæ, we have not only a direct dependence of these animals upon the season for their appearance, but the length of their life is actually limited by the duration of the year; and they are as much dependent upon the seasons for their existence as most plants, or as some of the insects. They pass the

greater part of the year in the more or less torpid state of egg-life, next grow into a polyp-like vegetation, which at a particular period produces a kind of bud; and this, flower-like, developes into a more highly organized structure, which is at last freed, and moves about independently. These animal flowers, as it were, (and the comparison to a flower is so striking, that, even now we know that there is nothing of a vegetable character in these animals, we cannot help using the term, as best expressing the impressions we derive from the sight of such living beings,) — these flowers move about for a certain time, until they are actually killed by the heavy showers of summer rain, — another analogy between the development of these animals and the growth of some plants.

Medusæ, of this species in particular, are very sensitive to the density of the medium in which they live, and the mere change arising from the difference in density between fresh water and salt water is sufficient to kill them almost instantaneously. Taking up in a spoonful of sea-water a fresh Sarsia in full activity, when swimming most energetically, and emptying it into a tumbler full of fresh water of the same temperature, the little animal will at once drop like a ball to the bottom of the glass, and remain for ever motionless, killed instantaneously by the mere difference of the density of the two media. This little experiment, which I occasionally repeated at different intervals during the past summer, has led me to the discovery, that the total disappearance of the small Medusæ from Boston Bay uniformly coincides with the heavy rains, while the larger species survive. Sarsia, Hippocrene, Tiaropsis, Pleurobrachia, Bolina, indeed all the small species known to occur here, disappear entirely after heavy rain-storms, a few stragglers only, which were probably moving at greater depths during the rain or concealed under more sheltered places, being found afterwards. These also disappear entirely at the next fall of fresh water. These little Medusæ occur in large numbers, swarming near the surface of the water, moving rapidly in all directions with the greatest freedom and energy. They are exceedingly voracious, and feed upon any kind of marine animals, not sparing their own species.

When kept in confinement, the water in which they are preserved should be changed frequently; but when kept in good condition they will live in captivity for a longer time; and when placed in large glass jars, they can be watched in all their movements, and very satisfactorily studied. They are, however, so transparent, that, to observe them successfully, it is necessary to place them towards the light, or to watch them at night with a candle behind the glass jar, when nothing about them can escape the attention of the observer; as the inner cavities, the tubes communicating with them, the progress of digestion, and circulation of the digested food, can be traced as perfectly as their gen-

eral movements, and also the manner in which they chase their prey, seize, swallow, and finally digest it.

It is indeed a wonderful sight, to see a little animal not larger than a hazel-nut, as transparent as crystal, as soft as jelly, as perishable as an air-bubble, run actively through as dense a medium as water, pause at times and stretch its tentacles, and now dart suddenly in one direction or another, turn round upon itself, and move suddenly in the opposite direction, describe spirals like a bird of prey rising in the air, or shoot in a straight line like an arrow, and perform all these movements with as much grace and precision, and elongate and contract its tentacles, throw them at its prey, and secure, in that way, its food, with as much certainty, as could a larger animal provided with flesh and bones, teeth and claws, and all the different soft and hard parts which we consider generally as indispensable requisites for energetic action; though these little creatures are, strictly speaking, nothing more than a little mass of cellular gelatinous tissue. (Compare Plate IV. Fig. 5 to 12).

The study of such animals is therefore of high physiological importance, as it will enlarge our views of animal functions, and give more precision to our ideas of cellular life; and the more so, because in this, as well as in several other naked-eyed Medusæ, we can satisfy ourselves with the greatest ease, that the different organs which perform here different functions are entirely and exclusively composed of cells; not in the same sense as it can be said of the body of higher organisms, but strictly so, — the cells here not undergoing any extensive metamorphosis by which they are transformed into distinct tissues of different structures, though derived from cells. Here they preserve the appearance of indisputable cells, combined in various ways, slightly modified in different parts of the body, but everywhere to be recognized as cells although performing the most heterogeneous functions. Here a heap of large cells, containing a crystal-like, more consistent fluid, constitutes the main mass of the body. Other series of somewhat elongated, more or less bottle-shaped, contractile cells, elongating and shortening alternately, constitute bundles or layers of an apparently fibrous tissue, which is, however, only an accumulation of slightly modified cells representing the muscular system, and acting as such with as much energy as the striated muscles; though here we have no muscular bundles proper, no primitive fibres whatever, no striation upon the contractile tissue, but cells, the walls of which are contractile and act as muscles. (Plate V.; the parts in blue.)

Other strings of similar, but more ovate cells, constitute the chain through which sensations are perceived, and which, probably, also transmit the manifestations of the animal individuality outwards. Here other cells form the walls of a digestive apparatus endowed with the most energetic power to dissolve animal substances, and separate the nourishing

from the refuse parts. Here other cells, which constitute a most powerful stinging apparatus, spread all over the tentacles, sending death into any other living creature of small size brought into contact with them. Here other cells, assuming in their combination the form of peculiar dark specks, perform, probably in a very low degree, the functions of the organ of sight, reduced, perhaps, to a faint discrimination between light and darkness. Here other cells, growing larger and larger, finally isolate themselves completely from the parent body, and give rise to new individuals.

Such is the wonderful simplicity of structure which is traced in these bodies, in which so much activity, so much energy, so many acts of decided volition, such strong appetites, such powerful movements, are constantly displayed, as might lead to the supposition that the structure was far more highly complicated and came much nearer to that of the higher animals: but upon the closest examination it is found to be made up of the simplest elements of organic structure, preserving almost completely their primitive simplicity, although in wonderfully diversified variety of combination and form. I do not know which in this organism is most wonderful, — the apparent simplicity of the whole structure; or the diversified indications of active life; or the complications and variety that the simplest elements of structure exhibit.

Our ideas of organic development of higher structures imply generally the corresponding idea of diversified systems of functions and organs, and thus we acknowledge a structural superiority of all animals in which distinct muscles, a distinct solid frame, a distinct digestive apparatus, and special organs of circulation and respiration, occur simultaneously; and we should consider as an inferior organization, that of animals in which we were to observe only simple animal walls, with one simple or ramified inner cavity. But this apparent simplicity might be counterbalanced by a great diversity of microscopic structures of the tissues; or the apparent complication of organization might be made to appear very simple, were it shown that the different tissues are simply modified cells. Such considerations respecting our estimation of the difference and resemblance which exist between animals are naturally called forth, when we remember that naturalists of high eminence have represented the Medusæ to be quite as perfect in their structure as any of those living beings which, from their resemblance to man, we have been in the habit of considering as the highest. Indeed, Ehrenberg would not grant to any animal a structural superiority over others, having succeeded in displaying such remarkable structures in many animals, which, before the publication of his investigations, were supposed to be either entirely structureless, or furnished with only the simplest apparatus.

Let it not be forgotten, now that we know more of the structure of these animals,

and of their developments, that, however diversified their parts are, their tissues remain in the lowest degree of structure, — in a condition similar to that in which all animals are found at a certain period of their life when developing from the egg; and if we apply such a standard to the appreciation of the structure of the Medusæ, we shall acknowledge that they are animals of a low character of structure, although this structure be highly diversified in itself.

There is unquestionably a nervous system in Medusæ, but this nervous system does not form large central masses to which all the activity of the body is referred, or from which it emanates. There is no regular communication by nervous threads between the centre and periphery, and all intervening parts; and the nervous substance does not consist of heterogeneous elements, of nervous globules and of nervous threads, presenting the various states of complication and combination, and the internal structural differences, which we notice in the vertebrated animals, or even in the Mollusca and Articulata.

In Medusæ the nervous system consists of a simple cord, of a string of ovate cells, forming a ring around the lower margin of the animal (Plate V. Fig. 11, 2, 4, 5), extending from one eye-speck to the other, following the circular chymiferous tube, and also its vertical branches, round the upper portion of which they form another circle. The substance of this nervous system, however, is throughout cellular, and strictly so, and the cells are ovate. There is no appearance in any of its parts of true fibres.

I do not wonder, therefore, that the very existence of a nervous system in the Medusæ should have been denied, and should not be at all surprised if it were even now further questioned after this illustration. I would only urge those interested in this question to look carefully along the inner margin of the chymiferous tubes, and to search there for a cord of cells of a peculiar ovate form, arranged in six or seven rows, forming a sort of string, or rather similar to a chain of ovate beads placed side by side and point to point, but in such a manner that the individual cells would overlap each other for one half, one third, or a quarter of their length, being from five to seven side by side at any given point upon a transverse section of the row; and would ask those who do not recognize at once such a string as the nervous system to trace it for its whole extent, especially to the base of the eye-speck, where these cells accumulate in a larger heap, with intervening colored pigment forming a sort of ganglion; then, further, to follow it up along the inner side of the radiating chymiferous tubes which extend from the summit of the vault of the body, and to ascertain that here, again, it forms another circle around the central digestive cavity, from which other threads, or rather isolated series of elongated cells, run to the proboscis; they will then be satisfied that this apparatus, in all its complication, is really a nervous system of a peculiar structure and adaptation, with peculiar relations to the other systems of organs.

From this state of things as observed among Medusæ, we should be prepared to find them endowed with the power of feeling, even if the sensitive cells were more diffuse, and did not appear as continuous chains; and this is probably the condition of the sensitive apparatus in the Polyp; in which, notwithstanding the care bestowed upon a thorough investigation of the tissues, I have not succeeded in discovering any thing similar to what is so plainly seen in Medusæ. There are, however, layers or heaps of peculiar cells in various parts of the body; but only the contractile cells assume a linear arrangement, a fibre-like disposition in particular rows.

We have here, therefore, a peculiar type of the nervous system, a type different from all those types which have yet been recognized in the animal kingdom. And such a nervous system I have already traced in all its details, as here described, in the genera Hippocrene, Tiaropsis, and Staurophora. The illustrations accompanying this paper are perhaps less complete for the Sarsia, though I first traced it in this genus; but afterwards some peculiarities of the genus Hippocrene, and especially the greater facility of keeping it alive for a long time under the microscope, and of watching all the minute structural details upon the living animal, have induced me to represent them more extensively from Hippocrene than from Sarsia, which, owing to its lively, active habits, is more difficult to keep in a steady position under the microscope, unless it be mutilated to prevent it from running about.

I may mention on this occasion, that all I have to say of the structure of Medusæ has been traced upon living individuals. I do not mean upon individuals taken out of the water alive to be placed under the microscope, but upon individuals preserved alive in narrow glass jars while under the microscope, surrounded by a sufficient quantity of water to keep them alive during the whole period of investigation, and to preserve them afterwards, to be placed again and again under observation; so that comparatively few specimens have been sacrificed for these studies, though a large supply was constantly at hand, that their habits and development might be watched.

In order to study the structure of marine animals in such a way, it is necessary to plunge, without hesitation, the objective glass into the water, as it were otherwise impossible to follow with sufficient quickness the animal in its motions, or to adapt the microscope to the proper focus, if it were to be alternating through the media of air and water, or through both together. By keeping it constantly under water, a great deal of inconvenience is avoided; and, with some practice, one succeeds soon in employing in such investigations even higher magnifying powers, such as systems I. 6 of Oberhäuser's microscope, and to reserve only the highest powers for more steady investigation, with a completely immovable apparatus. Without alluding to the advantage there

is in studying in this way all the tissues without destroying them by any pressure, it must be obvious that their special character can, under no circumstances, be better studied than when the tissues preserve the natural turgescence of life. Of course, such investigations cannot be traced otherwise than by the sea-side, with all conveniences for sedentary study.

The form of Sarsia mirabilis is very peculiar, and remarkably well adapted for its rapid movements. (Plate IV.) It is somewhat bell-shaped, hemispherical; with the upper vault broad and flat, and the sides rather prolonged, sometimes even in the relaxed state assuming a somewhat cylindrical form, which, when more contracted, gives the whole mass an almost hemispherical shape, which may, at times, really assume the appearance of a nearly globular body. And all these forms pass so rapidly from one into another, that it is exceedingly difficult to say which is the more natural. I have watched these animals, when they seemed to rest motionless in the midst of the waters (Fig. 1); they then had the most regular hemispherical form; the four arms, which then hung loosely downwards, would, from the base, stretch at right angles with the lower margin of the animal for a short distance, and then hang vertically downwards, for perhaps two or three times the length of the greatest diameter of the central mass. After remaining for a while immovable in that position, the walls of the body would relax, the arms elongate, the sides hang loosely downwards, and the whole body assume a more cylindrical form, when the arms hang straight downwards in graceful undulations, and without forming any marked angle with the base of the animal. (Fig. 10.) In this state of relaxation, the tentacles would elongate for three, four, and even more than five times the length of the greatest diameter of the animal: but if, suddenly starting from this inactive position, it contracts powerfully to move onwards, in its first contraction, or for several contractions repeated in quick succession, it assumes an almost entirely spherical form (Fig. 9), the thinner margins contracting more extensively than the main mass, and shutting almost entirely the lower opening of the body, the arms following in their undulation these quick contractions, which press the water out of the main cavity with such force as to push forwards in an opposite direction the whole body, which thus advances rapidly under the repeated contractions. After each contraction, and during the onward movement arising from it, the tentacles point directly backwards. During each contraction they are considerably shortened, and elongate gradually in the progress of locomotion. (Fig. 8, 11, 12.)

This animal seems very well to understand how to direct its course by its contractions, as it will dart downwards, if it be near the surface of the water when started, or it will move sideways if it be near the walls of the jar, or it will rise upwards if it be at its bottom; it will suddenly change its direction if it meets an obstacle, turn once or twice

upon itself in a revolving curve, and then dart again suddenly straight forwards in any given direction. Of course, the changes of form which it assumes in these different movements are almost endless: and though several are represented in Plate IV., they hardly give a complete idea of the beautiful diversity of aspect which this animal exhibits in its movements. What increases the variety of its aspects beyond the change of form of the main body, the shortening and elongating of the tentacles, and the shutting and opening of the main cavity, is the disposition of the proboscis, which is either entirely contracted within the main cavity near its upper centre, or hangs down to the margin of the opening, or stretches out between the tentacles for nearly as great a length as the whole diameter of the body, in either a straight line, or variously bent in graceful undulations, or curved upon itself. Though the usual form of these animals is rounded, it may be seen at times to contract in such a manner as to assume a flattened shape in its lower part by the compression of its sides: and this is especially the case when the animal turns round upon itself, and changes its direction in its movements. (Fig. 8.)

Again, when it pauses and remains in that state of rest for a longer time, the lower margin is frequently seen to assume a square or quadrangular form: especially when it is perfectly immovable, and the tentacles are stretched out at right angles from the lower margin for a considerable length. (Plate IV. Fig. 1.)

On watching minutely its outline, it will be observed that the sides are not always circular, but from the contraction of the layers or bundles of motory cells, it assumes a quadrilobate appearance, especially when those radiating bundles which alternate with the alimentary tubes are powerfully contracted.

The main bulk of the body consists of a gelatinous mass, forming the bell-shaped, central part of the animal. This is thickest above in the central part of the swollen disk (Plate V. Fig. 7, 11): towards the sides it gradually tapers, and becomes very thin near the lower margin about the origin of the tentacles, where it is suddenly turned inward at right angles with its previous direction, and forms the transverse separation between the main cavity of the body and the surrounding medium, a large hole, however, being left in the centre, through which the proboscis plays at ease. This lower opening (Plate IV. Fig. 2, 3, 4) is comparatively much wider than in the genus Hippocrene, and less so than in Tiaropsis and Staurophora.

At first, when watching the animal in its movements, it would seem as if the gelatinous mass itself were the cause of locomotion: but, upon close examination, it is easily found that it is merely an elastic support for the active apparatus of motion, which consists of layers and bundles of contractile cells diversely arranged. There is an external system of these bundles immediately under the epidermis, through the agency of which

the contracted body is restored to its expanded form. Upon the inner surface there is another system, which contracts the sphere, acting in antagonism with the former. These two systems consist of bundles extending vertically from the upper portion of the vault downwards. Within the inner vertical system, there is another one consisting of concentric transverse bundles, lining the cavity of the body, the direction of which tends to reduce the capacity of the space inclosed between the walls of the animal and the lower partition. A fourth system of circular concentric bundles is spread through the whole partition below. This system, in its strongest contractions, may shut almost entirely the main cavity of the body, and, like the pupil of the eye, it opens and shuts constantly. In its less powerful contractions, it assists the inner transverse and vertical muscles in reducing the capacity of the inner cavity, and when deeply contracted it helps more fully than any other part of the contractile system in forming the body into a sphere. We have thus here four distinct muscular systems, an external superficial system, an inner system parallel to the former, a concentric system of the main cavity, and a concentric system of the partition below.

It will be worth while to examine more minutely the arrangement of this muscular apparatus, as otherwise it might be difficult to form correct ideas of the movements described, and perhaps be supposed that the very existence of these muscles was not altogether so satisfactorily ascertained, if their arrangement could not be traced in detail.

Let me say, in the first place, that the outer coat of the animal consists of a layer of flat polygonal nucleated cells, forming, as it were, the external point of attachment for the external muscular system. Indeed, to this coating the superficial muscular system seems to be suspended, penetrating more or less into the gelatinous mass. The muscles, or rather the bundles of elongated cells, do not converge upon the summit. There is a circle, or rather a polygon of fibres (Plate V. Fig. 3), occupying about one third of the summit, from which vertical bundles run down to the lower margin. There are four main bundles of the kind, alternating with the eyes when seen from below. (Plate V. Fig. 4, *a*, and 3, *a*.) These bundles are the strongest of the external system; and when powerfully contracted, and especially when assisted by the inner corresponding fibres, they give the whole body a four-lobed appearance. They act in accordance with the inner system only in its most powerful contractions. In a state of repose, when the body is relaxed and the muscles slightly contracted, they however constitute a sort of antagonism with the bundles of the inner surface of the gelatinous mass. Besides these bundles, we have eight more following the same direction (Fig. 3 and 4, *b*, *b*), and occurring, also, in the intervals between two nutritive tubes, accompanying, therefore, at some distance, the main bundles already described, and bearing an evident relation to them,

though far apart; as they generally follow the modifications of the main bundles, sometimes arising almost from the same point, and at other times more apart, but evidently always lending their influence, in their contraction, to the action of these bundles. Seen from below (Plate V. Fig. 4), the whole system appears rather like a brush of muscular bundles diverging downwards, then slightly converging to meet the lower margin without uniting again, and forming there twelve bundles, four of which are stronger than the other eight. By this arrangement, the bundles appear more or less pennate as they converge or diverge. I may say, that this whole system of superficial muscles is never seen, but by its action, unless the specimens are dead, and have been dead for some time, when, during the contraction which follows death, they are made temporarily visible, and can then be traced with certainty in all the details of their arrangement, under the microscope. In Fig. 3, Plate V., small transverse superficial bundles are seen, connecting the secondary vertical bundles. In the two figures of Plate V., above cited, the inner muscular systems, and the digestive and chymiferous apparatus, have been drawn in outline, in connection with the more complete and finished delineation of the system of external muscles, in order to allow a comparison with Fig. 1 and 2, where the inner muscular systems have been drawn with particular care, and the outer omitted. The possibility of thus separating the investigation of these two systems, which otherwise cover each other so closely, will satisfy every one of the necessity of close investigation of these parts to understand them well. When highly contracted, they seem to run together. (Plate V. Fig. 6, *d*, *d*.)

The inner system (Plate V. Fig. 1, 2, 11) follows closely the same arrangement, both in the direction of the fibres, running vertically from the upper centre downwards, and in their mode of diverging and converging, by which they form similar pennate bundles; except that here the central bundles *d*, *d*, *d*, *d*, are more prominent than the two accessory ones, *e*, *e*, *e*, *e*, *f*, *f*, *f*, *f*, which follow them. Though these bundles are chiefly superficial on the inner surface of the gelatinous mass, they penetrate more or less into the gelatinous body, and their arrangement is so peculiar, that it cannot be compared with the arrangement of muscular fibres in any other group of animals. As described above, the gelatinous mass of the body is bell-shaped, thickest in its upper arched part, thinnest below, where the margin is bent inwards at right angles; and this whole mass is very elastic. Now the muscular bundles can neither be said to rest simply upon the inner or outer surface of this body, nor to rise within. There are bundles which lie outside or near the outer surface, and others which lie within the gelatinous mass, and others, again, which rise more or less obliquely from within, and extend towards the surface; so that the muscular bundles are properly loose bundles, the fibres of which penetrate unequally into the gelatinous mass;

and, as the inner and outer layers correspond to each other, they form a sort of partition thr oughthe gelatinous mass, though they do not meet in the centre. The form of the bundles themselves is very peculiar, inasmuch as the isolated fibres can be traced to more or less bottle-shaped cells.

The circular system of muscles (Plate V. Fig. 11, 1, and 2, *i*, *i*), lining the main cavity of the body, covers the inner vertical system, and forms a layer of fibres placed at right angles with it. But it does not merely pass over the vertical muscles, it also covers the vertical chymiferous tubes which diverge from the centre of the disk. These muscular bundles are parallel to each other, and cover regularly the whole inner surface of the disk, there being only a thin layer of loose epithelium over them. Fully to appreciate their position and mode of action, it is necessary to have a correct idea of the relation of parts on this inner surface of the body. From what has been said above, it is plain that the inner surface is divided into eight zones; the four inner vertical muscular columns and the four chymiferous tubes, which alternate with each other, form the lines of demarcation; and between two such lines, that is, alternately between one bundle of muscles and one chymiferous tube, and so on, there are muscular fibres, extending in gentle curves all over the inner surface of the body, beginning at a short distance from the central digestive cavity, which this muscular system does not surround, down to the lower part of the disk.

That this system of concentric muscles consists of eight vertical rows of concentric bundles, and not of circular fibres extending all round the inner surface, is shown by the different forms which these parts assume during strong contraction and after death, where evidently each system of these fibres, that is to say, each vertical row between a chymiferous tube and a vertical muscular bundle, contracts independently, and in its more or less powerful contractions forms more or less arched curves; and as the whole cavity, in its contraction, has more or less curved walls when seen from above or from below, these eight rows of concentric fibres appear to intersect each other in opposite curves, and to form two distinct systems in the upper and lower half of the body. But it can easily be understood from Fig. 1, 2, and 11, Plate V., that the fibres which appear arched inwards above belong to the same system as the fibres which appear arched outwards in the lower parts. It is not difficult to ascertain that this system of fibres covers the vertical chymiferous tubes, at its junction with them, and that there are some fibres running up and down along these tubes, especially near the eye-specks upon the posterior or inner surface of their bulb, where various fibres (Plate V. Fig. 2, *o*, *o*, *o*, *o*) rise from the margin accompanying the chymiferous tube behind the bulb.

Finally, there is a fourth muscular system in the lower partition (Plate V. Figs. 2, 4,

and 11, *g*, *g*); but this consists entirely of circular fibres or bundles, and these bundles constitute a continuous system all round the lower part of the body, not subdivided into distinct zones like the inner circular system, and thus showing itself to be a special, distinct muscular system. These muscles constitute a mere muscular membrane, stretched between the lower margin of the disk, and lined above and below with a single epithelial layer of very delicate cells. The muscular system itself does not consist of fibres running all round the circle, but of fibres identical with the common caudate cells of unstriped muscles, interlaced in such a manner as to form a regular membrane, the bulging part of some cells filling the space between the caudate appendages of the others; and forming in their intricate connection a flat muscular layer. It is, perhaps, easiest to trace, under high powers, the arrangement of the muscular bundles in Medusæ in this part of the body, where each contractile cell can be found to have its nucleus and nucleolus, but it requires great care not to mistake the cellular elements of the epithelium lining the two surfaces of this disk for the inner elements of muscular cells. With all the power of the best Oberhäuser microscope, I have been unable to discover the slightest indication of striæ upon the muscular cells: nevertheless it cannot be doubted that they are voluntary muscles. But it would be as unphilosophical to consider this fact as an objection to the distinction made in the higher animals, as it would be premature to infer that voluntary muscles should be striated muscular fibres everywhere in the whole range of the animal kingdom. The above description will show how widely a true muscular system, performing voluntary contractions, can differ in one class of the animal kingdom from what it is known to be in another.

The nutritive system, with its ramifications, gives a peculiar aspect to this genus, and contributes greatly to its remarkable appearance. From the mere impression derived from the powerful movements and the great activity of the proboscis of this animal, we should at once be led to suppose that it is a very voracious being, as energetic action is at least indicated by muscular power, when this has no particular reference to the swiftness of the motions. And, indeed, Sarsiæ are very voracious, and their proboscis-like digestive cavity, and their nettling appendages, are well calculated to seize upon living prey.

In the first place the nutritive system begins with a central proboscis (Plate IV. Fig. 1, 2, 3, 4; Plate V. Fig. 7, 11; also, Fig. 8, 9, 10), of considerable size and length in proportion to the bulk of the body. It hangs down from the middle of the vault, and assumes the most diversified forms in its various contractions, owing to the difference of structure of its different parts, the lower extremity (Plate V. Fig. 7, 8, 9, 10, 11, *o*), which is capable of the greatest dilatation, differing somewhat from the main body, *b*, and

this again from the upper portion, *c*, of the tube, which enlarges into a central cavity, *d*. This tube, or proboscis, when contracted, does not extend beyond half the depth of the main cavity of the body. It is even at times shortened beyond this limit. In its utmost state of contraction (Plate V. Fig. 10), the lower opening, *o*, is rather widened, and the proboscis may then be compared in some degree to the mouth of other Medusæ, though its margin, *a*, is not split into lobes. When relaxed, it either hangs straight downwards or forms undulations in its course, and hangs then generally, not only to the lower margin of the main cavity, but more or less beyond. (Plate V. Fig. 7, 8, 9, 11; also, Plate IV. Fig. 1, 6 to 12.) When greatly elongated, it may even hang between the tentacles, for as great a length as the greatest diameter of the body itself.

The upper part of the tube, *c*, *c*, *c*, in the centre, is always thinner than the middle and lower portions. To this middle part, *b*, *b*, *b*, the eggs are attached. But before examining minutely the structure of this apparatus, let us follow it further. From the central cavity (Plate V. Fig. 7, *d*), into which the proboscis empties, arise four chymiferous tubes (Plate IV. Fig. 1, 2, 3; Plate V. Fig. 1 and 3, *g*, *g*, *g*, *g*; 7 and 11, *e*, *e*, *e*, *e*), at right angles with each other, which communicate freely with the central cavity, as well as with the cavity of the proboscis. These four tubes, following the inner surface of the gelatinous disk, extend to its lower margin, where they are united with each other by an annular tube of the same appearance and the same diameter, forming a circular canal (Plate IV. Figs. 1, 2, 3; Plate V. Fig. 11, *k*, *k*) around the lower part of the disk, and this circular tube communicates as freely with the vertical radiating tubes, as those communicate with the central cavity; so that digested materials and water, by which the food is dissolved, and with which it is mixed in greater or smaller quantity, circulate freely to and fro in all this apparatus. It is astonishing how quickly an animal, swallowed by this little Medusa, is dissolved, and its particles circulated. The digestion takes place above the mouth, which shuts over the food, or is simply stretched upon the surface of the animal upon which it feeds, sucking its juices and dropping soon after its dead carcass. In that way the Sarsia swallows very quickly large numbers of other small Medusæ, and especially of the young of Aurelia aurita, and also other soft animals and small Crustacea; I have, however, never seen it swallowing the hard parts of any of these latter, but only sucking their juices between these lobes.

This liquid food moves on through the proboscis in jerks to and fro, under the contractions of the tube. It even takes some time for the contents of the stomach to pass entirely into the central cavity, into which they are pushed on, mingled with more or less water. But there is a constant process of regurgitation taking place, so that particles which were once near the upper end of the proboscis are now and then suddenly

eructated, or at least pressed out into the lower end of the proboscis, where the mouth, contracting closely, causes the proboscis to swell above, without allowing the food to escape, which may gradually retrace its way into the central cavity, then be circulated into the radiating tubes, reach the lower circular canal, and move about in it, sometimes advancing from the centre towards the periphery, at other times rising from the periphery towards the centre, and moving alternately one way or the other in the circular tube. There can be no doubt as to the irregularity of these movements, as the globules or granules suspended in the more liquid food will enable any one, even with a low power, to trace the course of the nourishing fluid.

The tentacles, also four in number (Plate IV. Figs. 1, 2; Plate V. Figs. 2, 4, 11, *l*, *l*, *l*, *l*), arise from the lower margin of the disk just at the points where the vertical tubes unite with the circular canal, and at these points we notice a sort of bulb (Plate V. Fig. 11, *m*, *m*), consisting of the swelling of the base of the tentacle in its connection with the chymiferous tubes, and also of a peculiar accumulation of cells, forming a rudimentary visual apparatus in the form of black eye-specks. (Plate V. Fig. 13, *a*, and Fig. 14, *b*; also, Fig. 7, *i*, and Fig. 12, *d*, &c.)

The presence of nourishment within the chymiferous system renders it more or less apparent to the naked eye. There is, however, hardly any state in this animal, in which the cross formed by the four tubular radii in their connection with the small narrow cavity and proboscis could not be distinguished, even with the naked eye. I may as well mention at once, that the cords of sensitive cells (Plate IV. Fig. 1, 2, 3; Plate V. Fig. 2, 4, 11) accompany everywhere the chymiferous tubes, so that the tracts which are made prominent to our senses by the color of the food circulated through these tubes are the most important points in the structure of these animals. The chymiferous system, in connection with the nervous system, marks, as it were, the most prominent feature of an animal, in which the muscular system alternates in the arrangement of its essential parts with these tracts.

The intimate structure of the digestive and circulatory apparatus is as follows. The proboscis consists of a tube, in which we may distinguish three layers of cells. There is an outer or epithelial layer, under which the eggs are developed, when the animal is mature. No eggs, however, are formed about the mouth, or in the uppermost part of the proboscis; the middle region of its tract alone is covered with crowded eggs, and to such an extent, that, at the spawning season, the proboscis (Plate V. Fig. 7, *b*) seems much thicker than under ordinary circumstances. The next layer consists of contractile cells; it is the most powerful layer, it is also thicker, and extends, in unbroken continuity, from the margin of the mouth to the central cavity. (Plate V. Fig. 8, *e*, *e*.) It is a kind

of muscular tube, in which, however, the tissues do not assume a membranous appearance properly, but rather preserve their cellular nature. On the inner surface, we find another layer of epithelial cells, *i*, *i*. The contraction of the cells of the middle layer can be seen so easily under the microscope, that, if any doubts should be entertained upon the question of cells, as such, being organs of locomotion, I would simply refer to an investigation of this proboscis. There are, however, some peculiarities about which I am not prepared to give a decided opinion. For instance, are the threads which extend between these contractile cells contractile fibres or sensitive fibres? As for the walls of the central cavity and the radiating vascular tubes, as well as the circular tubes below, they seem structureless; that is to say, the elements of which they consist cannot be traced beyond the main appearance, which is that of very thin membranes, and whether they are intercellular spaces lined with solidified gelatinous matter, or whether they are particular rows of cells, confluent into each other so as to form tubes, I cannot determine at present. But so much is true, — that the whole system of these peripheric tubes communicates in all its parts, and that the movement of the fluid within is not owing to the contraction of the walls of the circulating tubes, but is produced by the contractions of the proboscis, in which there is a distinct muscular layer, and by the general changes of form arising from the contractions of the voluntary muscles, and also from the contractions of the tentacles, which, by their base, are connected with the circulating apparatus. And although we have here a regular alimentary canal, and this canal branches off and assumes the appearance of a circulatory system, we have properly neither a digestive system, in the sense in which we acknowledge it in other animals, nor a circulatory apparatus; for there is no distinction between the alimentary canal proper and the vascular system, the one opening through large tubes into the other; nor is there a distinct circulatory apparatus, as the fluid circulated in these tubes consists of the contents of the stomach which have been emptied into them. Therefore we should be on our guard against comparisons involving identity of plan and of structure, when tracing the analogies or homologies between these parts. As far as I am concerned, I would prefer to call the central part of this system the proboscis, rather than to call it the mouth and stomach; I would prefer to call the narrow cavity above, the central, circulatory cavity, rather than to call it the heart, and I would prefer calling the vessels arising from it chymiferous tubes, to calling them either bloodvessels, or circulatory vessels, or alimentary vessels.

Another fact, which shows how little, — I will not say, homology, — but how little analogy, there is between such an arrangement of tubes and that of the vessels of higher animals, is this, that the sensitive swelling, — as every body will allow the eye-speck with

its bulb to be, even though its being an organ of vision should be denied, — that the sensitive bulb is so closely connected with the marginal tentacles and the chymiferous tubes, and is placed in such a radiating position along the margin of the animal, as to form an apparatus unparalleled in the animal kingdom.

The tentacles of the margin (Plate V. Fig. 2, 4, 11, *l*, *l*, *l*, *l*; Plate IV. Fig. 1, 2) have a structure very similar to that of the proboscis. They likewise consist of contractile cells, and also have cells of a peculiar character upon their external surface; but the degree of contractility is far greater in these tentacles, for they can shorten to a length considerably less than the diameter of the body, and extend to four or five times that length; and the quickness with which they retract and extend is most astonishing. These tentacles are hollow, and the liquid which circulates in the circular tube penetrates into their cavity up and down. They are gradually attenuated and nearly cylindrical when extended, but rather thick when contracted. There is not the slightest indication of an aperture or puncture at their end, through which fluid might be absorbed, or refuse matter from the chymiferous system rejected, nor is there any such opening in any part of the circular tube or of the other tubes through which the liquids are circulated.

The external surface of the tentacles (Plate V. Figs. 11, 12, 15, 16, 17; Plate IV. Figs. 1, 2) appears rough, granular, or rather tubercular; and, when elongated, these tubercles are sufficiently distinct to appear like rows of beads hanging loosely to several threads twisted together. But in their contracted state they come so close together, that the whole surface of the tentacle appears tubercular. Upon close examination, these tubercles are found to consist of heaps of minute epithelial nettling cells, arranged in the form of rosettes or mulberries, each of which contains within itself a thread coiled in a spiral, which may be thrown out like the threads of all nettling cells, and is provided at its base, or at the upper portion of the bulb formed by the cell, with a double hook. Similar cells occur, not only upon all the marginal fringes of the discophorous Medusæ, but even upon the tentacles of the margin of their mouth. I have, however, suppressed in this paper the graphic illustrations of their structure which I had prepared, having since discovered a highly complicated structure in similar apparatus in Polypi, which leads me to suppose that the structural details hitherto recognized in the nettling apparatus of Medusæ do not exhaust the subject. I foresee, indeed, that there are material additions to be made to what has just been mentioned, as soon as another opportunity is afforded to examine specimens of this animal. But whether their structure shall be found more complicated than it is at present supposed to be, or not, so much is certain, that the nettling cells, forming the bead-like granules upon the tentacles of Sarsia, throw out, under

artificial pressure, long threads, by which they no doubt seize upon their prey; as it is never observed that they coil the whole tentacle round any animals which they strike to death apparently by simple contact, and which remain adherent to the part of the tentacle with which they have been struck. This shows plainly that the nettling cells themselves, with their threads, must be the seizing apparatus; and though I have never seen, in the living animal, the threads turn out of the cell in this species, and have only noticed it in specimens acted upon by pressure, I have recently observed the fact of the inversion of the nettling cells in Polypi so distinctly, that I have no doubt as to the identity of the operation in both cases.

The discovery of these nettling lassos in so many animals provided with tentacles, and which had never been seen to use their tentacles to secure their prey, but which seemed rather to retain it by some magic power, will at once account for all the difficulties. Though the tentacles taper uniformly for their whole length, they are comparatively rather thickened near the base, where their swollen wall forms a kind of support for the numerous minute pigment-cells which constitute the bulb of the eye, among which a few pigment-cells, of a larger size, grouped closely together, constitute a dark, brilliant speck upon the outer and upper part of this bulb. This is another curious adaptation in nature, where the organ of sight is combined with one which is destined to catch the prey, and where the main apparatus for distinguishing at least between light and darkness, if not for perceiving distinct images, is imbedded in a heap of cells, which form also part of the thick wall of the tube through which the fluids circulate. This combination is so remarkable, that it is worth while to pause a moment and consider the particular disposition of this bulb, its intimate structure, and its relation with the different parts around it.

The sensitive bulb, as I may call it (Plate V. Figs. 12, 13, and 14), is placed, as already mentioned, at the junction of the marginal tentacles and the circular vertical tube, which pass into each other on their inner surface. It forms a marked projection, and is of an irregular triangular form, with rounded edges. Seen from below (Figs. 2 and 4), it is divided into two halves bulging sideways, between which the marginal tentacles arise (Fig. 13). Seen in profile (Fig. 13), the dark eye-speck appears still more prominent, in the shape of a hemispherical body projecting above the base of the tentacle. Seen from above and outside (Fig. 14), it is more pear-shaped, the vertical tube, *a*, above the eye-speck appearing like a continuation of its upper end. The circular tube (Fig. 13, *c*) opens sidewise towards its lower margin, and so far behind its edge as to appear less connected with it on each side when seen in front. (Fig. 12.) The whole mass of the swollen bulb consists of various kinds of pigment-cells, and other cellular uncolored

tissue, which may be an accumulation of sensitive cells; for the nervous tissue, or rather the circular nerve, which follows the marginal circular tube, enters on both sides of the bulb (Fig. 2, 4), within its substance. And as this nerve itself consists simply of a string of ovate cells, I have scarcely any doubt that the transparent cells distributed among the pigment-cells of the bulb are sensitive cells, as well as those which are arranged in a distinct cord around the inner margin of the circular chymiferous tube. In the centre and on the outside of the bulb, there is a heap of larger pigment-cells grouped together so closely as to form a distinct, dark speck, which may be considered as an eye proper, or rather as the apparatus which absorbs the light, and transmits it to the sensitive elements of the tissue underneath. That such an eye, if it be an eye, cannot properly be compared to the eyes of higher animals is plain, from the fact that the dark pigment is placed here between the light and the nervous mass, and therefore rather intercepts the image than receives it. But it may act as a condenser of light, and give rise to different sensations in the dark, and under the direct influence of light. We may, therefore, consider such an organ as a rudimentary eye, perhaps incapable of perceiving distinct images, as there is no transparent lens to refract the rays of light, and combine them in a focus. But in the transition between such dark specks of pigment matter connected with nervous masses, and regular eyes or ocelli, there are so many intermediate stages of structure in the animal kingdom, that it were unphilosophical to deny the connection between the function which such an apparatus performs and the functions of ordinary eyes.

The difference, however, is sufficient to warrant the introduction of another distinct appellation, and justifies us in designating such imperfect apparatus of vision as "eye-specks." It has been said, that they might be apparatus adapted for the perception of heat rather than light; but when we reflect how slight is the change of temperature of the medium in which these animals dwell, we are less inclined to take such a view of this organ, and we would only acknowledge that the perception of the calorific rays of light without a distinct perception of the colorific rays might be none the less a sort of vision, if we reflect upon the intimate connection there is in nature between heat and light, and if we further consider, that, in the series of animal structures, we pass from apparatus clearly constructed as eyes to those in which these organs, becoming more and more numerous, appear on the surface of the body, rather like parts of the system of their coloration, and therefore also as parts of their adaptation to be more or less influenced by different sorts of rays of light. When describing Hippocrene and Pleurobrachia, I shall have an opportunity to show how little ground there is for considering these dark specks as organs of hearing.

I have little to add upon the nervous system, after what has been remarked above. Its structure is the same wherever it occurs in naked-eyed Medusæ, consisting of ovate cells, arranged in strings, which are, however, more elongated in Sarsia than in Hippocrene. The main cord is that which extends along the lower margin of the body, forming a circle close to the inner side of the circular chymiferous tube. This cord, however, is not continuous all round the animal, as the four sensitive bulbs are interposed in its circumference. We should therefore view it, in this type, as four strings connected by four ganglia, in which the thread-like arrangement is lost in the mass of the bulb. As for its position, it follows the inner margin of the chymiferous tube, and may be easily recognized upon any point of the circumference, close to that tube, on its inner margin; near the bulb it rises distinctly towards its base on its posterior side, into which it merges. Contractile fibres placed on the sides of this ganglion, and a thickening of the substance of this part, prevent a clear perception of the sensitive elements in their connection with the bulb; but parts of this system rise along the vertical tubes on their inner side, and follow their whole tract up to the central cavity, around which they form another ring, connecting the four vertical threads and encircling here, again, the central parts of the alimentary cavity. From this upper ring, thread-like cells may be traced downwards along the proboscis; and, as already mentioned, I am almost convinced that they follow the whole tract of the proboscis between the epithelial and muscular cells. Again, along the main bundles of vertical muscles, there are similar threads, which seem also to belong to the sensitive system, and to unite with the circular cord below, between the main bulk of these bundles, at their origin from the lower margin.

The resemblance, however, between the many variations of form in the contractile cells, (from the appearance of mere caudate cells to that of bicaudate cells, or mere thread-like cells,) and the numerous modifications of a similar kind observed among the sensitive cells, is so close, that I do not yet venture, in every case, to distinguish between them; so that, among these various sets of apparatus, which I have referred to two distinct systems, there may be some of the elements which belong truly to but one system, and it will require still more extensive investigations to decide with any certainty whether the proboscis is provided with sensitive cells at all, and whether the threads between the muscular cells are also muscular, or whether the shorter cells between the vertical, muscular bundles are nervous cells. Even some cells joining the upper ring, and accompanying it, may be only motory cells, and not sensitive elements.

But whatever be the final result of the investigation upon these few points, so much is already ascertained, — that there are rows of sensitive cells distinct from the contractile cells, though their constituent elements are very closely allied in their structure; and

that the main cord of the sensitive system extends round the lower margin between the eyes, and is connected with other cells forming a row behind each vertical tube, and another row round the central digestive cavity; and that distinct muscular contractile cells occur in four different systems, following different courses, which are easily distinguished in the main from the sensitive cells.

After arriving at such results, and upon comparing the elements of these tissues with each other, and finding them so near alike, it may even be questioned whether there is so strict a distinction between their functions in these low animals as we notice in higher types. And I should not be at all surprised, if it should be ascertained that even the cells of the circular, sensitive cord below contract in the motions of the animal, as well as the truly muscular cells; and if these cells, in their turn, should be found to enjoy the power of feeling or perceiving impressions similar to those which act upon the truly sensitive cells. So much, at least, is certain, that the nettling cells, which are truly epithelial cells, are capable of contracting or throwing out the coiled thread within them, and of being excited to perform their functions; — which would indicate in them, also, a certain degree of sensitiveness. Indeed, there is no philosophical ground for considering the structural elements in any way more distinct from each other in their nature, than their real structure warrants, which is throughout cellular; and where we have animals of a large size, living as these do, and performing such complicated functions as these are known to perform, without any other constituent elements besides cells, there is no reason to consider each set of these cells as absolutely distinct in its functions. I would mention in particular, that I have ascertained, by direct observation, that many of the threads which Dr. Will has described as connected with the upper ganglion in Beroe, are contractile threads, notwithstanding their connection with a distinct ganglion. Should it be objected, that this would only go to show that Dr. Will has mistaken muscular fibres for nerves, so much would remain clear, — that here muscular tissues combine intimately with nervous tissues, a mode of combination unknown in other animals. This circumstance, at all events, goes to support the view which I entertain of the subject in general, that the elements of structure in Medusæ have not yet reached that degree of distinctness and independence which they present in other groups of the animal kingdom.

There is another point in the structure of Sarsia which deserves particular notice. Above the central cavity may be observed a little knob rising into the gelatinous substance of the upper portion of the disk, brightly colored, and somewhat resembling the four bulbs of the lower margin, consisting, as the bulbs themselves, of a number of pigment-cells. The form of this knob varies in different individuals of this species, according to their size and age. In the youngest, when about a line in diameter, just when

they are freed from their hydroid polypidom, it has the form of an acute cone, reaching to the very surface of the dome-shaped disk, while, in more and more advanced individuals, it grows broader; the pointed summit is reduced, and finally this knob appears as a more or less hemispherical mass above the central cavity. This organ is a sort of umbilicus; it is the remnant of the canal by means of which the Medusa bulb was attached to its hydroid polypedon, and which undergoes the change just described, as soon as the connection has been broken between the maternal stem and the young animal.

This knob seems to me analogous to that black organ, which, in Beroid Medusæ, has been considered as a central eye, or as an organ of hearing, and below which a ganglion is seen. It remains to be ascertained, by embryological investigations, whether, in Beroe, this eye-like bulb is developed in the same manner as the knob of hydroid Medusæ, and whether it undergoes there, after detachment, a higher development to assume the appearance and functions of an eye-speck. That this may be the case seems probable, when we consider the relation of the two sorts of apparatus in the two types. The upper nervous ring in Sarsia bears the same relation to the central alimentary cavity and to the pigmented disk, that the ganglion and eye-speck of Beroe bear to the chymiferous system, which opens above its gelatinous disk notwithstanding these openings.

As for the organs of reproduction, I have already mentioned that eggs are developed along the greater part of the proboscis, between the muscular cells, and the external epithelium. These eggs have the same structure as all primitive eggs, being nucleated cells of a peculiar kind, destined to acquire greater independence, and to be cast, after their germinative dot and vesicle have grown to a certain size, and the transparent yolk inclosed in the vitelline membrane has been transformed into a granular, cellular mass; when they are extruded by the repeated contraction of the proboscis, and are dropped to undergo their independent development. But upon this point I shall enter into more details in another part of this paper.

One of the most instructive anomalies which I have observed in the genus Sarsia is a modification in the number of parts which I have once noticed in the common species of these shores. Though I have examined many hundred specimens of the Sarsia mirabilis, I have always found it to present the most uniform arrangement of its parts, the specimens having, in every instance, shown four eye-specks, four radiating tubes, and four bundles of radiating muscles, on the outer and on the inner surface of the disk. But, in one instance, two specimens were noticed, among many others, in which the parts were arranged in six (Plate V. Fig. 5); there were six tentacles, six eye-specks, six radiating chymiferous tubes, and six bundles of muscles. The specimens were somewhat

larger than the common four-rayed specimens, the disk measuring about half an inch; and I for a moment suspected this to be a distinct species; but, upon close examination, I found that every part was so perfectly identical with the corresponding parts of the four-rayed individuals, that I not only failed to discover the slightest specific distinction, but should even feel unwilling to recognize this as a variety. I should rather view it as a mere accidental modification of the number of parts, of no more importance in the range of specimens than the accidental development of an additional spur on the foot of a cock, or an additional finger to the hand or paw of an animal; — perhaps more striking here, as it ran through all the systems and influenced the general appearance of the whole body. But wherever we have an additional number of parts, we see everywhere that those tissues and systems of organs which belong to such parts are naturally developed in it; and so it was in this six-rayed Sarsia.

The six eye-specks were all identical in the details of their structure, and identical with those of the four-rayed ones. The connection between the circular tube and the radiating ones was the same, and the muscular bundles presented the same arrangement in relation to the lower margin, and intervening radiating tubes, as in common specimens. But if these six-rayed Sarsiæ had no importance whatever with reference to specific distinction, they were none the less of great interest with reference to the value of the number of parts in different genera of the same family of naked-eyed Medusæ. For, if a change in number, such as was noticed in this species, can occur without a modification of the specific character, we shall be prepared by this example to consider those genera in which the number of rays, or tubes, or ovaries, or eye-specks differs, as more closely allied than would otherwise appear. A variation in the number of parts in this family, when the parts are otherwise identical in structure and adaptation, will no longer be considered as a natural foundation for distinguishing families. They may indicate distinct genera, if the differences in number are combined with some modification in adaptation. But, however constant the differences in the number of parts may be, if they are not combined with some special adaptation in one or the other of the systems, I should not consider them even as warranting generic distinction, as we see in the case before us that such differences do not even warrant specific distinction.

This case of Medusæ with different numbers of rays is precisely parallel to the case of star-fishes with a variable number of rays, such as have been described by the older Linck, who, unfortunately for himself and the progress of science, considered each variation in this respect as indicating generic distinctions; when he might easily have ascertained that several species vary greatly in this respect.

HIPPOCRENE.

I HAVE selected the genus Hippocrene for a special consideration of the naked-eyed Medusæ, for the very obvious reason, that it can most easily be managed under the microscope when alive, owing to its smaller size, and also, in some degree, to its peculiar form, which makes it easier to keep it in a given position. This genus was established nearly simultaneously, and quite independently, by two different authors. Mertens, during his voyage round the world, saw a species to which he gave the name of Hippocrene, which was described and figured in the Transactions of the Imperial Academy of Sciences of St. Petersburg, for the year 1835. Lesson, on the other hand, described it in the *Annales des Sciences Naturelles*, under the name Bougainvillia.*

All we know at present of the structure of this remarkable genus is to be gathered solely from the sources just mentioned, and from Lesson's work on Acalephæ, forming one of the continuations of Buffon, published by Roret. Professor Forbes has added most valuable information upon the British species. There is, however, one point in the history of this animal as yet entirely unsettled. The other naked-eyed Medusæ seem to be all derived from hydroid Polypi, but the generation of Hippocrene has not been sufficiently traced to have led to the knowledge of its alternate generation; and though I have seen its eggs laid, they are so minute as to escape the attention of the naked eye, when dropped into water. The suggestion I have made,† that Hippocrene might be the free generation of Tubularia, rests simply upon certain analogies between the germs developed in the ovarian bunches of Tubularia and the full-grown Hippocrene, and by no means upon a direct investigation of its metamorphoses. It remains, therefore, to be seen, whether Hippocrene is really the alternate state of existence of Tubularia, or whether it originates from some other hydroid Polyp.

That Hippocrene should be one stage of generation of some hydroid Polyp is made more probable, since the true relations of this little Medusa with Sarsia and other naked-eyed Medusæ have been fully ascertained, and I expect that it will be found to be

* Although Professor Edward Forbes, in his *Monograph of the Naked-Eyed Medusæ*, has preserved the generic name of Lesson in preference to that of Mertens, upon due consideration I am inclined to go back to the name of Mertens; for, though Forbes mentions the year 1829 as the date of Lesson's genus, I cannot find any definite indication of its establishment prior to the year 1836, in the *Annales des Sciences Naturelles*. It is true Lesson was the first to describe the species upon which this genus rests; but he established it under the name of Cyanea Bougainvillei in Duperrey's *Voyage round the World*.

† *Lectures on Comparative Embryology.*

a universal character of this family, to multiply alternately by eggs producing polypidoms, and by buds arising from these stems to produce free Medusæ. The genus Hippocrene is easily recognized by its hemispherical form, its four bunches of tentacles, with numerous eye-specks at the meeting of the vertical tubes with the circular marginal one; and also by its quadrangular, pendulous, central digestive cavity, from the margin of which hang numerous branching fringes. This general appearance of Hippocrene is so peculiar, as at first to suggest the propriety of separating it into a distinct family; but upon tracing the homologies between all parts through the whole family of naked-eyed Medusæ, it cannot escape the attention of the philosophical observer, that all these animals form members of a natural, intimately connected series, and that it would be a gross exaggeration of the differences which they exhibit to subdivide them into families. The main features are in all the same. There is a central cavity (Plate I. Fig. 1–4), here somewhat larger and much shorter than in Sarsia, from which arise four radiating chymiferous tubes which meet along the lower margin, with a circular tube of the same character, precisely as in Sarsia. Through this system, the digested food is circulated, and the granules floating in liquid move to and fro from what might be called here also a stomach, through the radiating tubes, into the circular one below, and back. There is nowhere an inlet or outlet to this system, excepting through the mouth, which is surrounded by numerous tentacles, branching repeatedly. These tentacles are only the fringed margin of the mouth itself, and should, therefore, not be considered as something peculiar to Hippocrene; nor is the mouth in any way peculiar, as it forms here, as in all other naked-eyed Medusæ, a circular radiating opening.

The most striking generic peculiarity of this type is the pendulous position of the stomach or proboscis when seen in profile (Plate I. Fig. 1), which neither enjoys the great power of extension and contraction which characterizes Sarsia, nor is reduced to the small size peculiar to Staurophora, nor so pressed against the upper disk as in Tiaropsis. It is here a square mass, more or less star-shaped in its outline, when seen from above (Plate I. Fig. 3, 4), or from below (Fig. 2); not longer than it is broad, but which, morphologically speaking, answers strictly to the proboscis of Sarsia. The analogy is the greater from the position of the sexual apparatus in the two genera; eggs and spermatic cells arising in both only from the external walls of this central organ. The color of the stomachal bulb, however, is very peculiar, inasmuch as in different individuals of the same species it is either pale-yellow, or orange, or simply purple and brown; no doubt this coloration is owing to peculiar cells lining its inner surface, which may have something to do with digestion, and perhaps may be analogous to hepatic cells, though I have been unable to satisfy myself on this point.

The origin of the four chymiferous tubes, which arise from the upper corners (Plate I. Fig. 1) of this cavity, shows still further the intimate relation there is between the structure of Hippocrene and that of the other genera of the family. Perhaps the arrangement of the tentacles might be a more difficult point, as in Sarsia we have only one long tentacle, with one eye-speck at the confluence of the vertical and circular tubes; while in other genera, such as Tiaropsis and Staurophora, there are many isolated tentacles all round the lower margin of the disk, larger ones alternating with smaller ones, either each provided with an eye-speck, or only the larger ones, or the eye-specks alternating with the tentacles. But if we take into consideration the curious genus Lizzia, of Forbes, where there are alternately two and three tentacles more closely united, with a single eye-speck to each bundle, there will be no longer any difficulty in acknowledging in Hippocrene only an extreme in the combination of tentacles, grouped altogether in four bunches, with the additional peculiarity of having as many eye-specks as there are tentacles; — an extreme, I say, of the arrangement foreshadowed in Lizzia, where fewer tentacles form similar bunches. Thus we are gradually led to consider as belonging to the same series those naked-eyed Medusæ in which the tentacles are arranged in a single row, as Thaumantias, Willia, Circe, Oceania, Turris, Stomobrachium, Geryonia, and Geryonopsis; and those in which they are combined in bunches, as Lizzia and Hippocrene; and those in which they are reduced to a few isolated tentacles, as in the genera Sarsia, Slabberia, and Modeeria; and even those in which there is one single tentacle developed, as in the genera Euphysa and Steenstruppia.

A thorough comparison of the other generic peculiarities throughout this family will sustain equally well my position, that the naked-eyed Medusæ constitute a single natural family; and that the modifications noticed in different genera are only generic modifications, and not indications of distinct families. The fact that the tubes branch before they reach the circular tube, as is the case in Willia, is of no greater importance than the fact, that individuals of the same species may have a larger or smaller number of such tubes. For though generally the number of these tubes is constant in one and the same species, we have seen Sarsia mirabilis with six rays, six tubes, six tentacles, and six eye-specks, and the bundles of muscles follow the same general arrangement, according to the fundamental number displayed in those specimens, just as the number four prevails in others. Of how subordinate importance this ramification of tubes may be will appear still more evident, when we take into consideration the diversity there is in that respect among the common discoid Medusæ. And, also, to refer to genera of this very family, we cannot but be struck with the little importance of these ramifications as the foundation for families, when we compare the genera Berenice, Staurophora, and Eudora.

The question about the value of the position of the ovaries is one of great importance. In Sarsia and Hippocrene, we have the eggs developing upon the external walls of the proboscis or central digestive cavity. In Tiaropsis, Thaumantias, and others, we have the ovaries on the outer surface of the radiating tubes, while in Staurophora we have them in an intermediate position. This last fact shows the little importance there is in the position which the sexual organs assume in these animals; for, even if we had not this intermediate disposition in Staurophora, I would not hesitate to bring together genera like Slabberia and Sarsia, which can hardly be distinguished as genera otherwise than by the disposition of the ovaries; and though Circe has eight radiating tubes, and eight ovaries, this difference does not remove it in the slightest degree from Thaumantias. Circe and Thaumantias are as nearly allied as genera of the same family can be, and, indeed, between them there is no other difference than in the number of radiating tubes; and we know already, from Sarsia, that this is of little value. Saphenia, also, when compared with Oceania, may show the slight importance these numbers have; for the value of the genus Saphenia as a generic section may fairly be questioned, when we see Oceania with four, with eight, and with more tentacles, the chief generic character of Saphenia being to have only two such appendages.

Now if the position of the ovaries around the central part of the digestive cavity, or upon its radiating tubes, is not a character of sufficient importance to warrant a distinction of higher order than a generic distinction, we can be led to a more natural arrangement of the genera of this family than that proposed by my friend, Professor Forbes; but I do not wonder, that, with all his philosophical acumen, he has been led to exaggerate the value of these characters, for he first pointed them out, he first recognized these fundamental differences, and we all know that the first step in the recognition of facts is to exaggerate their value, and that we hardly come to a correct appreciation of their real importance unless we have exaggerated them. This kind of natural exaggeration is, after all, the only test of the value of facts; and I have no doubt, that, in his own mind, and probably by the progress he has made since he gave the scientific world the admirable results of his investigations, Professor Forbes himself must have found that the distinction of six families among naked-eyed Medusæ does not rest upon the existence of six fundamental types of structure, but upon various combinations of the fundamental elements of one very natural group, for the recognition of which we are indebted to him.

Though groups more or less similar to that of the naked-eyed Medusæ, as circumscribed by Professor Forbes, have been introduced in former works upon the natural history of this class of animals, — though we have in Eschscholtz the families of

Geryonidæ, Oceanidæ, Equoridæ, Berenicidæ, which constitute his natural group of Discophoræ cryptocarpæ, answering closely to that of Forbes's naked-eyed Medusæ, — it is now obvious that Eschscholtz's division of Discophoræ cryptocarpæ rests upon the ignorance of their true mode of reproduction, rather than upon any fundamental common character; and though he alludes to the absence of what he calls the eight marginal granules, which we now call eye-specks, and which are known to exist also, but in another form, in the naked-eyed Medusæ, still this division rests altogether upon an imperfect knowledge of these animals. Lesson himself, though his work is published at a period when so many facts had been ascertained respecting the structure of Medusæ, did not recognize the common structure of this type, and subdivides it into various families without a common character.

The characters common to all naked-eyed Medusæ consist, in the first place, in the general character which they have in common with all other Discophoræ, to which great order of Medusæ they belong, implying the existence of a gelatinous disk, and a central digestive apparatus. In the naked-eyed Medusæ, this gelatinous disk is generally more hemispherical, and less flattened than in the larger Medusæ with protected eyes; also, as far as I can ascertain, all naked-eyed Medusæ have a continuous circular tube, into which open the few radiating vessels which arise from the central cavity of the digestive system. It is true, in the common Discophoræ, there is also a marginal connection of the radiating branches of the chymiferous system. But there it is rather an anastomosis of minute vessels, while here we have a regular circular tube, in which fluids move to and fro, and into which the radiating tubes open largely. This circular tube forms so prominent a feature in the structure of the naked-eyed Medusæ, that it marks out the lower or peripheric margin of the animal, and that the eye-specks, tentacles, and all the various ornaments of the margin of the disk seem to be connected with it, or to arise from it, or to be more or less dependent upon it; and, indeed, from the large supply of nourishment constantly circulating in the circular tube, I have no doubt that the life of the parts surrounding it is more active and intense than that of any other part of the body, owing to the regular, fresh supply they receive from the digestive cavity. The main cord of the nervous system itself is connected with this circular tube, and follows it on its inner margin all round. Muscles in vertical bundles outside and inside of the gelatinous disk regulate the locomotion, assisted by a system of circular fibres upon the inner cavity, and another within the partition, which stretches more or less extensively from the lower margin inwards. Tentacles, varying extraordinarily in number and size and arrangement, arise from this same lower margin, and the eye-specks themselves are placed in the same position, either between the tentacles, or upon their base, or their inner or outer surface.

In Sarsia, for instance, they are upon the outer surface of the base of the tentacles; in Hippocrene, upon the inner surface.

Another character common to all naked-eyed Medusæ consists in their central mouth. Though many of them have been described as deprived of such a central aperture, there can no longer be any doubt respecting its existence in all the well-characterized genera of the family. Extensive differences may be noticed in the form of the mouth, and in its connection with the inner cavity, but these differences are nowhere such as to warrant more than generic distinctions. In Staurophora, it is a mere fissure, in the form of a narrow extensive cross in the centre of the lower surface of the disk, with low fringes all round its edges. In Tiaropsis, the opening is reduced to a small space in the centre, but the margin of the mouth forms more extensive lobes, with thin, light fringes. In various genera, this central cavity forms a sac more or less developed, hanging from the centre, either with a simple margin, or with a lobed and fringed opening. This central sac may assume a more permanent shape, as in Hippocrene, or be of a more movable nature, as in Thaumantias, or even be developed into a very protractile and retractile proboscis, as in Sarsia. In Hippocrene, we have perhaps the maximum of division in the margins or lips encircling the mouth, as they form here a kind of dichotomous tentacles; while in Sarsia the margin of the mouth is entire. Again, the organs of reproduction are found in all, upon the outer surface of the digestive cavity, whether they encircle the main, central cavity, or follow the radiating tubes.

The characters of the naked-eyed Medusæ may therefore be easily summed up in this way. A gelatinous disk with a reëntering margin; — a central digestive cavity with radiating tubes meeting a circular tube along the margin; — tentacles and eye-specks along this margin; — mouth and central cavity varying in size and form, but opening in all in the centre; — reproductive organs following the chymiferous system; — and a distinct nervous ring along the circular marginal tube observed in all; — generation alternate, one form Polypoid, and the other Medusoid.

After having characterized the genus Hippocrene as above, and traced its intimate relation to the diversified forms referred to the type of naked-eyed Medusæ, I shall now proceed to illustrate the minute structure of this animal, which I have been able to investigate satisfactorily in almost all its details. Form and structure are so intimately connected in these low animals, I may say in Radiata at large, that the one is almost the expression of the other, in a far more strict sense of the word than in any other group of the animal kingdom. And this is so true, that giving a complete description of their form is already to intimate the general arrangement of their organs, and that the description of their organs can never be full, unless it is mentioned in relation to their form.

We should, therefore, not wonder at the fact, that the zoölogical descriptions of the lower animals include so much more of structural details than the descriptions of any other group of animals. The truth is, that here it is impossible to characterize genera or even species without alluding to structural details, just as it is hardly possible to give a sketch of their structure without indicating the principal varieties of form under which these animals appear. And it is of great importance for the progress of zoology in general, that this should be the case; for, as the study of radiated animals has, of late, excited more interest than before, it will have a beneficial influence upon the other branches of zoölogy, in carrying over into all its departments the methods now employed in the description of these lower types; when the results of comparative anatomy and embryology will be united to form one great picture of the whole animal kingdom, as is already the case in the study of Radiata.

It is really an unexpected circumstance, that the investigations of the lowest animals should lead to the most appropriate and natural method of studying, describing, and depicting animals at large. But if we consider how, in these Radiata, and perhaps in Medusæ more than in any other group, the changes which they undergo during life are intimately connected both with their habits and changes of structure, it will be obvious that the study of their metamorphoses is entirely inseparable from the study of their structure, and that, again, this study is intimately connected with that of their habits; so that, in this class, the natural history of these animals is truly what it should be in all classes, an illustration of their form, of their structure, and of their embryonic development, as well as of their respective habits. It is highly desirable that this method of studying animals should be universally introduced; and as soon as it is done for those classes which, from their peculiar structure, have left remains of their former existence buried in the strata which constitute the crust of our globe, another point of view will equally be connected with those other considerations, — I mean, the study of fossils; when those isolated doctrines of natural history, comparative anatomy and physiology, embryology, and paleontology shall be viewed universally as mere subsidiary departments of one science, — that of the development of life.

In Hippocrene the form is particularly striking, and there is hardly any type among the naked-eyed Medusæ in which it preserves a more permanent appearance; for this animal, during its motions, is less liable to extensive changes in its outline than any other genus.

The gelatinous disk which forms the main mass of the body is so much bent over downwards, and its margin so extensively bent inwards, as almost to close the body, and to give it nearly the form of a regular sphere. (Plate I.) The contraction of the disk

below, and the width of the partition across the lower opening, prevent both an extensive spreading and very powerful contractions, in consequence of which the movements are reduced to repeated jerks, and the whole animal seems rather to jump from place to place by its sudden contractions, than to dart in one direction and to bend in various ways, as the Sarsia does, or to progress slowly by repeated uniform contractions, as we observe in Tiaropsis and Staurophora. In its natural position when at rest (Plate I. Fig. 1 and 5), Hippocrene stands upright in the water, its tentacles more or less drawn out and stretched outside at various angles from the lower margin. The tentacles, however, in that position, may be more or less contracted. When fully drawn out (as in Fig. 1, 2, 5, 6), they are longer than the diameter of the body itself; but when fully contracted (as in Fig. 4 and 11), they are very short and hardly visible isolately, but form simple bunches of curved threads. If immovable, with retracted tentacles, the animal seems to sink slowly lower and lower in the water; but with the tentacles stretched out, it remains more steady in the midst of the water, and does not seem to change perceptibly its place. As soon as it contracts to move, the tentacles are reduced to a certain middle state of extension (as in Fig. 3), and brought together in a backward direction (as in Fig. 9 and 10); but when dilating, they are drawn in through the lower aperture in an inverted position (as in Fig. 7 and 8). From its peculiar form, this animal turns easily every way, and moves with equal ease and elegance sideways or downwards, or obliquely in all possible directions, as Fig. 7, 8, 9, 10, 11, show. The arrangement of parts, however, is such, that, during the most powerful contractions, the lower opening is brought into a square form, as noticed in Fig. 2, 3, 4, 9, 10, but when gradually relaxing passes again into a more rounded shape, as in Fig. 1, 5, 8, 11. When at rest, as in Fig. 1, it is perfectly circular, and only the more straight course of the inferior chymiferous canal, extending from one sensitive bulb to the other, preserves some indication of the quadrangular outline. As far as I know, the species of Hippocrene which lives on the shores of Massachusetts is the smallest perfect Medusa known. At least, I have not observed any species with perfectly developed eggs of so small a size as this. Fig. 5 to 11, indeed, though intended to give a correct idea of this animal in its natural appearance, have been enlarged to twice their natural diameter, or at least exaggerated one half, as I have never seen a single specimen fully equal in size to Fig. 11. But, as it would have been almost impossible to give any thing like correct outlines of this little creature without enlarging it, I have preferred to exaggerate somewhat its size, even in drawing its natural attitudes, rather than to omit such details as will alone give a correct idea of its particular appearance. Fig. 1, 2, 3, and 4, represent some of its attitudes considerably enlarged. Fig. 1 is a profile view, slightly turned, to show, through the transparent

mass, the parts of the whole body in their natural position. Fig. 2 represents a specimen seen from below, looking into the main cavity of the body, with all the tentacles fully drawn out, in order to show the lower opening, the mouth, and its tentacles, the main digestive cavity, and the four rays which arise from it, and curve downwards to reach the four bulbs, from which the tentacles arise. In this figure it is plainly seen that the tentacles are inserted upon a triangular, or somewhat crescent-shaped bulb, and that there is an eye-speck at the base of each on its lower surface. From this bulb the tentacles diverge somewhat in the form of four bunches, and, on comparing this figure with the upper figure, it is easily ascertained that the tentacles are stretched upwards in such a manner as to form a sort of radiating arch stretching upwards and outwards, the bulb being then slightly turned outwards. Between the four bulbs, a canal is observed assuming an almost quadrangular form, though its four sides are slightly arched outwards. The respective position and relation of these parts are further well shown in Fig. 1, where the large, central brown bulb represents the central digestive cavity, which is nearly quadrangular, or almost cubical with prominent angles, and from the lower corners of which arise four bunches of tentacles surrounding the mouth, which last is placed in the centre of the lower surface, as seen in Fig. 2. The angles of the mouth project in the same direction as the bunches of its tentacles, which are also developed in the same direction as the four chymiferous tubes arising from the upper corners of the digestive cavity, so that the radiation of all parts takes place in the same direction. These four radiating chymiferous tubes first rise upwards, and are then arched over sideways, to turn downwards and finally meet the four sensitive bulbs below, following in their course the inner surface of the gelatinous mass. This mass has a prominent rounded discoid projection upon the centre of its lower surface; thus causing the central digestive cavity to hang, as it were, downwards into the main cavity of the body, though in fact it arises, as in other genera of this type, upon the lower surface of the gelatinous disk. But this surface being not uniformly arched, but prominent in its centre, the parts seem to have here a very different arrangement; and, had it not been ascertained, by a vertical section through the centre, that the middle portion of the gelatinous disk bulges downwards, it might have been supposed that the central digestive cavity was hanging loose below the disk, and was suspended to the four radiating chymiferous tubes.

The branching tentacles of the corners of the mouth hang downward, in their natural position, as seen in Fig. 1. They are naturally foreshortened in Fig. 2, where they are seen from below. The difference shown in these two figures in the form of the sensitive bulbs and in the fringed eye-specks arises, also, solely from the position of the animal.

They are seen in profile in Fig. 1, and appear to form a flatter arch than in Fig. 2, owing to the oblique position of the bulb, and the circumstance that the tentacles, with their basal eye-specks, are inserted upon its prominent edges. The waving lines which are observed in Fig. 2, 3, and 4, between the bulbs and outside of them, indicate the different layers of muscular bundles lining the main cavity on the inner surface of the gelatinous disk. Seen in profile, as in Fig. 1, they appear like vertical supports, curved somewhat in the form of the letter S. The undulated outlines of the cavity in its upper part, between the arches of the chymiferous tubes, arise also from the undulations of the muscular system around the bulging projection of the centre of the gelatinous mass. Fig. 3 and 4 both represent the same animal seen from above; but the differences noticed in the central mass arise from the circumstance, that, in Fig. 3, the main digestive cavity is quite empty and contracted, and assumes there the form of a cross, with short arms, from which the radiating chymiferous tubes arise above, as the tentacles of the mouth arise below; while in Fig. 4 the main digestive cavity is filled and dilated, — so much so, that its prominent corners pass almost insensibly into the radiating tubes; and what gives it the appearance of a still larger organ is the circumstance, that its lateral walls are covered all over with minute eggs. It was, no doubt, owing to the presence of egg bunches alternating with the prominent corners of the mouth, that Mertens, in his description of this genus, has characterized the central cavity or stomach, as he calls it, as formed of eight distinct suckers, four larger and four smaller ones, alternating with each other. But the central cavity is really square, and has only four prominent angles, and this appearance of eight suckers arises simply from the development of eggs, which are formed between the prominent angles of the main cavity, upon the outer surface of its lateral walls. Moreover, these figures differ the more, as in one of them, Fig. 3, the tentacles are partly retracted, and in the other, Fig. 4, completely drawn in.

I need not say, that I have found it very difficult to ascertain the true relations of all these parts. Whoever will take the trouble to compare my figures with those of other species of this genus will, no doubt, acknowledge that I have spared no pains in endeavouring to make out the real structure of these minute, soft-bodied animals. As mentioned above, their slow movements, and their habit of resting quietly, suspended in an immovable position in the midst of the water, have somewhat facilitated the investigation; and their habit of remaining quiet, at times, when turned upon their side, or even when reversed, with the lower opening upwards, has been an additional advantage in this study. I may say, that I have been successful in investigating all parts in their natural relations in the living animal, with powers as high as Ocular 1, Objective 6, of Ober-

häuser's microscope, and that I could apply any higher powers after cutting the body into halves; for thus, without being sensibly altered, it would spread enough to admit of its being placed under glasses of very short focus. Some details, however, were examined from fragments cut entirely free.

As there are few systems of organs so conspicuous in the body of Hippocrene as the digestive system, I shall begin the minute descriptions of the parts of this animal with an illustration of this apparatus, as a knowledge of its arrangement is the best preparation to trace further the relations of other systems, and their combinations. Mertens was undoubtedly correct, when he ascribed a mouth to the genus Hippocrene; and Brandt, in his more extensive description, when publishing the notes of this able observer, was no doubt mistaken when he supposed that the fringes arising from the main central cavity were a kind of suckers, by which the animal pumped its food in a liquid state. I have, over and over again, seen the central mouth opening and shutting, and assuming the most different outlines, as it contracted or expanded; and, from a microscopic investigation of the surrounding tentacles, I can positively say, that they are deprived of any kind of opening at their termination, and are simply organs of prehension.

When shut, the mouth forms a prominent tubercle (Plate II. Fig. 18, *a*), between the four bunches of tentacles, presenting a fissure in the form of a cross upon its apex. This proboscis-like protuberance is a sort of protractile and retractile lip of whitish cellular tissue, which, from its great transparency, is easily overlooked upon the dark ground of the central cavity. This transparent tissue, however, forms the whole surface of the central cavity (Fig. 18, *b*, *b*, *b*, *b*); it extends, also, sideways into the peduncle of the tentacles, and rises upwards along the corners of the quadrangular mass, but it is really capable of considerable dilatation and contraction; for, though the mouth may be protruded so as to bulge out between the tentacles for nearly half the diameter of the central cavity, as represented in Plate II. Fig. 18, it spreads, at times, into a flat, nearly star-shaped opening, as seen in Fig. 23, *b*, with a more or less undulating margin. In this form the lips are considerably attenuated, and a narrow central cross-shaped fissure (Fig. 23, *c*) appears in the centre as the entrance (Fig. 23, *a*) to the central cavity. When examined from above in such a state of dilatation, as the upper wall of the central cavity is very thin, it is easy to see through it, and the opening appears then as a small four-rayed star, as in Fig. 19, 20, 22. The same appearance is also observed from below, as drawn in Plate I. Fig. 2. But the mouth is capable of a still further dilatation, when the narrow central opening is spread to the same extent as the lips, and the whole inner surface of the central cavity is seen through the opening, as in Plate II. Fig. 21. In

such a state of dilatation, the mouth is almost square, and nearly as wide as the main cavity, the lips being more or less sinuous. (Fig. 21, *a*.) In this condition of utmost dilatation, the continuity of the transparent mass of the lips with the base of the tentacles, *b*, is very obvious. The peduncle of the tentacles itself appears then simply as a prolongation of the mouth, protruded in the form of a branching margin. Here, the analogy of the mouth with that of the common Medusæ, such as Aurelia or Cyanea, is very obvious, the only difference being, that the branching fringes are not so membranous, but rather dendroid.

The tentacles of the mouth, (Plate II. Fig. 18, *c*, *c*, *d*, *d*; Fig. 21, *b*, *c*, *c*, *c*; Fig. 23, *d*, *d*, *e*, *e*, *e*; Fig. 25, 26,) like the lips, consist of a transparent cellular tissue, composed of two layers of different cells. The inner layer, which forms the main stem and the centre of the branches, consists of larger polygonal cells, (Fig. 25, 26, *b*, *b*, *b*,) while the outer layer consists of much smaller stinging cells, (Fig. 25, 26, *c*, *c*, *c*,) provided with an inner arrow-head (Fig. 27), like all nettling cells. Around the top of the branches of the tentacles, these latter cells are arranged in bunches, in such a manner as to give each termination the appearance of a sucker. But even when employing the highest magnifying power, I could discover no trace of an opening, but only the stinging cells in their regular arrangement. That these tentacles cannot be organs of suction is plainly shown by the fact, that their branches are not hollow, but consist of continuous cells. Their function, as indicated by their structure, can only be that of retaining the prey. The number of terminal ramifications in each bunch of tentacles is about one hundred, each tentacle dividing first into two branches, which are somewhat unequal, and then subdividing dichotomously, but also somewhat irregularly; for each of the bunches of the second order is subdivided so far as to contain, one about twenty, and the other about thirty terminal branches; amounting together to about one hundred terminal points in each tentacle, and making, therefore, about four hundred of these branches around the mouth. Each of the tips is surrounded by about a dozen stinging cells, varying in number according to the size of the branches, being more numerous in the larger branches and fewer in the smaller ones, and more numerous in old specimens than in younger ones. When fully open, as described above, the mouth allows a sight into the centre of the digestive cavity, which appears as an undulating surface, with honeycomb-like irregular depressions, (Plate II. Fig. 21, *e*, *e*, *e*,) lined with an epithelium of a dark-brown color. Whether the deeper brown cells under this epithelium are to be considered as hepatic cells, and whether these little depressions are secreting cavities, I am unable to decide; but I should incline to suppose that there are active functions going on in these tissues, and that the different layers of these cells do not perform the same functions, as the cavity contains always

mucosity mixed with brown matter. The cross-like figure in the bottom of this cavity, as seen from below when the mouth is open, (Plate II. Fig. 21, *d*,) indicates the folds in the roof of the digestive cavity, from which the radiating tubes arise.

The digestion takes place very rapidly; for the same specimen which, when brought in from the sea, had this central space widely distended, as in Plate I. Fig. 4, showed it soon after reduced to a more contracted star-shaped body, as in Plate I. Fig. 2 and 3, and Plate II. Fig. 22, where *b* indicates the empty cavity, *c* its prominent angles folded together, and *a*, *a*, the four prominent external corners. The upper corners of the central cavity are narrowed into the four radiating tubes, as seen in Plate I. Fig. 1, 2, 3, 4, and in Plate II. Fig. 18, 19, 20. Their connection with the main cavity seems not the same under all circumstances. When the central cavity is very full and distended, the tubes seem to be almost direct continuations of the main cavity, as in Plate I. Fig. 4, and to taper gradually into the tubes above; but when contracted, the communication between the central cavity and the tubes is nearly closed, and the tubes seem to arise like ligaments from the upper surface of the cavity, as seen in Plate I. Fig. 3.

Owing to the various dilatations and contractions of this part of the main cavity, its prominent corners assume various outlines. They appear, when half distended, like the rays of a star, as in Plate II. Fig. 19, 20; and then their continuation into the tubes is almost direct, though a slight contraction may be noticed at the base of the tubes, as in Plate II. Fig. 20. In this state, when the main cavity is partly empty, the areolar structure of the inner surface may be noticed equally well from above, through the wall of the body, as from below, through the opening of the mouth; as is shown in Plate II. Fig. 19, 20. There can be no doubt, therefore, that the whole inner surface of the central digestive cavity has the same structure, and performs throughout similar functions. But this areolar structure, and the lining epithelium, with the brown cells underneath, disappear at the base of the radiating tubes, and through their whole length nothing similar is noticed. Their walls consist of a homogeneous transparent tissue, through which the digested food is seen to circulate.

The fact that these tubes may be shut at their base, and thus temporarily cease to be connected with the digestive cavity, shows that the food is not admitted into them before it has undergone a certain degree of elaboration. But no sooner has it been reduced into a certain state of fluidity, in which the particles of the nourishing materials appear like little globules, than they open, the nutritive fluid passes into the radiating tubes, circulates regularly through these tubes along the inner walls of the disk, and through them passes into the circular tube around the lower margin. I have never seen in this species a regurgitation of the digested materials into the main cavity, and it

hardly could be visible through the opaque walls; but I am disposed to admit that such a backward current discharges, from time to time, the refuse materials into the main cavity. Indeed, undulatory movements of the globules (Plate II. Fig. 20, *b*, *b*) suspended in the liquid are frequently seen in the upper part of the tubes, and the contents of the main cavity hardly leave any doubt respecting the fact, that the undigested materials return to this cavity to be discharged through the mouth. If, upon these facts, we attempt to form a precise idea of the nature of the process of digestion and circulation of the nutritive fluid, we remain satisfied that the food introduced into the stomach is there transformed into chyme, under the influence of the epithelial coating and of the secretion issuing from the brown cells which line that cavity and form the inner layer of its tissue; and that when transformed into a homogeneous mass, or into chyme, it is discharged into the radiating tubes, and circulated through the body.

The fluid thus circulated and used as nourishment, and assimilated by the parts to restore their deficiency, to increase their tissue, and to contribute to the growth of the animal, is not blood; nor is it crude food; it is chyme, properly speaking, but chyme which is circulated, like blood, through a regular system of vessels. But these vessels cannot be compared to blood-vessels, nor this circulation to a regular blood-circulation; for the tubes communicate directly with the main digestive cavity, and the fluid circulated discharges its refuse parts back into that cavity; so that we have here a circulation *sui generis*, and a nutritive fluid also *sui generis*, which can only be compared to chyme. For if we take the most comprehensive view of circulation, and include under this function the distribution of nourishing fluids of every kind, then we must say that the lowest stage of development of the blood, the lowest condition in which that fluid is circulated, is that which answers to the chyme of higher animals; and this view will be justified, however strange it may at first appear, by a further comparison of the fluids circulated in the vessels of other animals, if we reflect that, in Articulata and Mollusca, even in those which have a heart, the fluid circulated is not blood properly, in the same sense as the blood of Vertebrata, but chyle. If these views are correct, we should be justified in saying that, in Radiata, *chyme* is circulated; in Mollusca and Articulata, *chyle;* and in Vertebrata only, *true blood*. This view is further sustained by the microscopic examination of the circulating fluid, which consists of globules most heterogeneous, both in respect to their size and their intimate nature, being merely comminuted particles of the digested food.

As for the tubes themselves, they form, for the circulation of the chyme, a closed system, which consists of four tubes arising from the upper corners of the central digestive cavity, and uniting at the lower margin with another tube running round that margin.

The vertical tubes do not form so simple an arch as in the genus Sarsia; for in Hippocrene the lower surface of the gelatinous disk is not simply arched; but there is in its centre a more prominent knob, below which the central digestive cavity hangs. This knob, with the central cavity, forms, therefore, a very prominent mass in the centre of the main cavity of the body; and the chymiferous tubes, which arise from the upper corners of the digestive cavity, have first to ascend along the gelatinous protuberance, and then merely bend over in a narrow arch before they descend along the lateral walls of the main cavity to reach the base of the sensitive bulb. The curve which all these four tubes describe is that of the crosier. (Plate I. Fig. 1.) As the upper portion of the disk scarcely ever changes its form, but slightly contracts and dilates, we perceive no marked change in the curve of these corners, and the changes in the direction of the current of chyme are consequently less frequent than in Sarsia.

To these immovable central parts of the animal, we must, no doubt, also ascribe the special adaptation of the central digestive cavity, which is precisely the reverse of that of Sarsia. In Sarsia, the extremely elongated form of this cavity allows it to be used as a proboscis, stretching in all directions for the food, and snapping at it with the greatest quickness and precision. Here the same organ is changed into a square, immovable, large cavity, the opening of which is capable of a most extensive dilatation, and surrounded by immovable branched tentacles, the surface of which is covered all over with nettling cells, by the agency of which the prey is retained. The appendages of the border of the mouth, by their peculiar structure and power of dilatation, perform in Hippocrene the same office with reference to securing the prey as the exceedingly active proboscis of Sarsia, which is, at the same time, both a catching apparatus and the digestive cavity. The chymiferous tubes are nearly as apparent upon the disk of the animal as the central digestive cavity, the nourishing fluid which is circulated in them being generally of a light-brown color. The position of the tubes within the main cavity is also characteristic. They are not attached loosely to the inner surface of the gelatinous disk, but follow its more permanent outlines, being kept steady both by the muscular bundles which extend in a circular arrangement round that surface, and by the epithelium which lines it. Their position is properly between this circular or concentric layer of contractile muscular cells, and the gelatinous disk itself, alternating with the main vertical masses of muscular fibres. Yet these tubes are not a mere furrow or canal hollowed out between other tissues: they have distinct walls of their own, which are exceedingly thin, structureless, homogeneous, and transparent, consisting of a hyaline membrane, in direct continuation, however, with the walls of the central digestive cavity, as may be seen from Plate I. Fig. 1 and 4, and Plate II. Fig. 7, 8, 9, 10. Their diameter is uniform for their whole length.

It is, however, at times more or less distended, owing to the greater or smaller quantity of fluid circulated in them. The lower part of the vertical tube is movable to some extent, inasmuch as it is situated along that portion of the gelatinous disk which alone is subject to considerable movement by the contraction of its muscular bundles. This lower portion of the tubes, however, is generally curved outward, (Plate I. Fig. 1,) so that it does not meet the base of the sensitive bulb from above, but from its inner surface, as is well shown in Plate I. Fig. 1, and in Plate II. Fig. 11, *e*, 13, *b*, and 17, *d*, *d*. It might seem at first as if the bulb at the base of these vertical tubes was a mere sac placed between the vertical tubes and the circular one of the lower margin, and it has really been described as such a pouch or sinus; but nobody, so far as I know, has as yet perceived that there is a connecting tube between the four bulbs. Neither Mertens, nor Brandt, nor Lesson, though all claim originality for their investigations, has seen any such connection, and Professor Edward Forbes himself does not seem to have noticed it, though he has known such a circular tube to exist in other allied genera. Now this circular tube in Hippocrene is situated in the same relative position in which it occurs universally in other naked-eyed Medusæ, extending in a circular disposition from bulb to bulb, (Plate I. Fig. 2, 3, 4; Plate II. Fig. 11, *b*, *b*, 13, *a*, *a*, 14, *e*, *e*, and 17, *a*, *a*,) and forming along the lower margin a continuous canal. Along the inner margin of this tube, the nervous cord is distinctly seen, under no very high power of the microscope, as shown in Plate I. Fig. 2, 3, 4; Plate II. Fig. 11, *a*, *a*, 14, *f*, *f*, and 17, *b*, *b*. But as here the eye-specks and tentacles are grouped in four bunches, the circular tube is stretched more directly from one bunch to another, and though arched outside, it assumes an almost quadrangular form. In it, as well as in the vertical tubes, the circulation of most heterogeneous granules, moving to and fro in all directions, and up and down through the vertical tubes into the horizontal circular one, can easily be traced, even under low magnifying powers.

So little is known of the structure of these animals, that I do not suppose that any particulars respecting it will be thought superfluous, and I may, therefore, be permitted to dwell at greater length upon the connection of the vertical and horizontal tubes with the sensitive bulb. This very prominent part in the little Hippocrene, which to the naked eye appears like a tuft of threads with dark specks at the base, consists of very heterogeneous organic elements. In the first place, I may say that it is by no means hollow, as it has been supposed; that the tentacles themselves are also not hollow; and that there is no direct communication whatsoever between the bulb and the chymiferous tubes. The fact is simply, that, as a normal organic adaptation in all these animals, the sensitive apparatus follows closely the disposition of the digestive and circulating apparatus. And, as I have already mentioned above, all these systems of organs are everywhere in direct re-

lation with the very form of the animal. But if there is no organic communication between the tubes and the bulb, we should not overlook the circumstance, that, before reaching the base of the sensitive bulb, each vertical tube, as figured in Plate II. Fig. 8, is dilated, and divides into two tubes, *b*, *b*, which are the connecting branches of the circular tube; or, in other words, on the inside of the inner surface of each sensitive bulb, there are three tubes meeting in a common triangular dilatation, (Fig. 8, *a*,) and this sac-like dilatation rests upon the inner surface of the sensitive bulb, and constitutes the connecting ampulla between the vertical and circular tubes. (Plate II. Fig. 11, *e*, *b*, *b*, and 13, *b*, *a*, *a*.) It does not seem to me that this sac-like dilatation is to be considered as any thing more than a mere swelling of the tubes at their point of junction; but I can easily conceive how such swellings may be found of larger dimensions, assuming the functions of pulsating sacs, or becoming a kind of heart, which would be here chymiferous hearts, in contradistinction from chyliferous or blood hearts of the higher animals. But the vascular swelling of Hippocrene is so small, that it can hardly be considered as such. It is rather a varicose dilatation of the tubes themselves; and, though I have noticed that this cavity is at times wider than at others, I have been unable to see it beat.

The whole chymiferous system, therefore, consists here of the four vertical tubes and the circular tube, without any ramifications into the tentacles, containing a fluid which is circulated to and fro in all directions. How nutrition is effected by this apparatus cannot easily be appreciated, unless we assume that there is an active process of endosmosis going on between this cavity and its contents and the surrounding tissues. The intimate connection of the sensitive bulbs with the nourishing system is so striking, that I cannot but insist again and again upon this feature in the structure of these animals. No doubt there is an organic connection between them more intimate than the mere relation of apposition; for the branching of the tubes corresponds with the swelling of the nervous cord into the large ganglia, and the dilatations of the chymiferous system, which might in some respects be considered as chymiferous hearts connected with the inner surface of the sensitive bulb, show further a more mutual dependence of these parts. Whether the circular tube should be considered as one tube, or as four distinct tubes extending each from one bulb to another, and meeting there with the vertical tubes, is a question of no importance whatever, as soon as it is understood that there is a free passage from each vertical tube, in two opposite directions, into the circular tube below, and also a free passage behind each bulb from one arc of the circular tube to the other, as may be inferred from Plate I. Fig. 2, 3, 4, and seen in Plate II. Fig. 8, 13.

The nervous cord, following closely the course of the circular chymiferous tube, is placed along the inner margin of that tube. It can easily be seen, either from above or

from below, whenever a perfect view of the whole circular tube is obtained, and is actually drawn as a thread with double outlines in the figures above quoted, as well as in those representing the muscles, and more particularly in Plate II. Fig. 11, *a*, 14, *f*, 16, *c*, and 17, *b*, *b*. Under a low magnifying power, this cord appears simply as a thread following the chymiferous tube. (Plate I. Fig. 2, 3, 4.) When I first noticed it, it appeared to me as a small thread; and though its structure was not fully recognized then, its connection with the sensitive bulbs led at once to the appreciation of its real nature as the main cord of the nervous or sensitive system. The difficulty of distinguishing between the tissues in this part of the body where so heterogeneous organs meet together, has rendered it for a long time difficult for me to ascertain the real nature of this cord. For here we have also circular muscles, or contractile fibres, which move the transverse partition of the lower part of the disk; we have an outer and an inner epithelium; and finally, the walls of the chymiferous tubes, which, at times, present themselves with so strongly defined outlines, that when the tube is not in its natural position, but more or less twisted, the sensitive cord does not appear on its margin as a distinct thread with peculiar outlines. But all the conditions for correct investigation of the facts having been assumed, I have repeatedly satisfied myself and others, that there is, along the inner margin of the chymiferous tube, a cord differing in its microscopic structure from all the contractile fibres and from all the epithelial cells around it, which follows the whole course of this circular tube, and enters into the lateral corners of the sensitive bulbs, where it forms part of their mass.

This cord, examined under high magnifying powers, such as Ocular 3, Objective 8, of Oberhäuser's microscope, appears as a string of several rows of nucleated cells, ovate in their form and placed with their longer diameter in irregularly continuous lines (Plate III. Fig. 13); that is to say, the cells are not strictly placed in juxtaposition by their ends, but alternate more or less, so as to form a cord-like mass, the elements of which are ovate cells placed side by side, their tips interposed between each other. This arrangement and the form of the cells make it easy, after the organ has once been seen, to recognize it again in whatever position it may be observed, and of late I have frequently been able to trace it upon the circular tube, passing obliquely across it, or following it in an oblique direction, whenever the parts had been twisted. Tracing this cord for the whole course of the circular tube, we see it penetrate into the angles of the sensitive bulbs, (Plate II. Fig. 11, *a*, *a*, 14, *f*, *f*, and 16, *c*,) in which its cells mingle with colored pigment-cells in such a manner as to form a compact ganglion of heterogeneous elements, rather than a nervous bulb. Of this, however, presently. Let me first remark, that in Plate III. Fig. 14, the nervous cord, *c*, is figured as it is usually noticed between the other organs; *a* being the sensitive bulb, *b* the chymiferous tube, *c* the sensitive cord, and *d* the

muscular partition of the lower side of the body. Fig. 13 of the same plate represents a portion of the same cord freed from all the surrounding tissues, with its well-characterized isolated cells of somewhat unequal size, and irregular, though chiefly linear, arrangement.

As for the bulb when seen with the naked eye, it appears simply as a dark speck, (Plate I. Fig. 5 to 11,) from which the tentacles issue. Under a moderate power, say of from ten to twenty-five diameters, it appears like a crescent-shaped projecting mass, (Plate II. Fig. 11 to 17,) thickest towards its base, thinner towards its prominent margins, and varying in apparent form in consequence of the different positions which it assumes. When stretched out laterally, (Plate II. Fig. 12, 14, 16, and Plate III. Fig. 14,) it is almost crescent-shaped or semicircular; and specks are noticed along its margin at the base of each tentacle. The substance, also, of the bulb presents then a regular arrangement, the pigment-cells being disposed in conical masses, with their points turned towards the black dots, while their wider bases unite in a semicircular dark mass. The same appearance is observed, whether we look at the bulb thus stretched from above or from below. The radiating cones of dark pigment-cells, however, are more distinctly seen from below, as is evident from Plate I. Fig. 2, or Plate II. Fig. 12, 14, 16, and Plate III. Fig. 14, when contrasted with Plate I. Fig. 3, 4. Seen from the edge in that stretched position, the tentacles being bent downwards, (Plate II. Fig. 13,) the position of the tentacles, which extend further inward on the upper side of the bulb than on the lower side, prevents a correct appreciation of the structure of the bulb. The black specks, however, which are placed on the lower surface of the tentacles, shine through, and form a double curve of black spots, the middle of which stands higher than the lateral parts, for a reason which will be obvious presently. If the tentacles are raised, but the bulb remain in the same position, (Plate II. Fig. 11, and Plate I. Fig. 1,) the basal part of the bulb is easily distinguished, and the black specks appear clearer, as they are now seen directly. In this position it can easily be ascertained that the chymiferous tube is really distinct from the bulb, and placed behind it, and that the nervous cord, Fig. 11, *a*, *a*, reaches the bulb on its inner lower margin.

Seen from the edge, (Plate II. Fig. 11 and 13,) the bulb appears narrower, or is not so high as broad. In this position, especially when the tentacles are raised, (Fig. 11,) the whole relative arrangement of parts is most distinctly seen. The chymiferous tube, as well as the sensitive cord, *a*, *a*, is traced to the base of the bulb, and the somewhat triangular ganglion, *c*, of the base, which is faintly seen in Fig. 13, is here more strongly marked. Seen from below and fully stretched out, (Plate II. Fig. 14,) the triangular ganglion, *d*, *d*, is still more clearly seen, and the radiating pigment-cones most distinctly noticed. The black specks, Fig. 14 and 16, *a*, *a*, *a*, form a curved series arising from the

lower margin of the bulb at the base of the shorter outer tentacles, where they are smallest and nearest the chymiferous tube. They gradually recede, however, more and more from the base of the tentacles, rising upon a slight prominence of their lower surface, and growing larger and larger, till we observe the largest at the base of the longest of the middle tentacles, with a very prominent black speck. When contracted laterally (Plate II. Fig. 15), as constantly occurs when the animal shuts its lower opening by the contraction of the inferior muscular partition, the bulb is folded up, and then divides into three unequal masses, the middle folds following the margin of the longest tentacle, and the two lateral masses answering to two bunches of lateral tentacles. When, on the contrary, it is fully spread out, but seen from the edge, as in Plate II. Fig. 13, it is almost triangular, or rather flat crescent-shaped, its surface is smooth, and the specks are seen through the tentacles. From these observations, it must be plain that the bulb is not hollow, but that it consists of a mass of dense cells arranged in a particular way. A triangular dilatation (Plate II. Fig. 14, *d*, *d*) at the base inwards consists more of sensitive cells, upon which are arranged, in a somewhat semicircular disposition, small, dark pigment-cells, grouped together towards the periphery to form prominent cones, the points of which are surrounded by more transparent parenchymatous cells, which form the base of the tentacles. The eye-specks at the base of the tentacles are not directly connected with the pigment-cells of the bulb; they form more compact and darker dots by themselves, in little prominences of the lower surface of the base of the tentacles, as seen in Plate II. Fig. 1, *a*. The accumulations of pigment-cells, which constitute the eye-specks, appear either as spherical or as circular disks, and assume at other times an ovate shape, or even the form of crescents. These various appearances must be the consequence of the arrangement of the cells, for they are always more or less circular, when seen from above or through the tentacles (Plate II. Fig. 13), and they assume a more crescent-shaped form when the tentacles are raised and the eye-specks are seen from the edge. I conceive, therefore, that they have the form of watch-glasses, lining the sac-like projection of the base of the tentacles, and that the crescent-shaped appearance arises either from the curve of the projection at the base of the tentacles, or from the circumstance of their being seen more or less in profile, or from both circumstances combined. But one thing is plain, — and a very important circumstance it is, — that the pigment-cones (Plate II. Fig. 12, 14, 16) of the bulb point to the centre of the eye-specks, which shows a close connection between these dark dots and the centre of the bulb where the nervous ganglion is seated; and though this is not an arrangement known in the organs of vision of any other animals, we are at least reminded by these peculiarities of the structure of the compound eyes of insects, in which the pigment-pillars intervening between the

nervous mass at the base of the eyes present a structure not very different from that of the radiating cones in the bulb of Hippocrene; and I cannot help finding in this analogy an additional argument in favor of the opinion which considers the marginal specks of Medusæ as a visual apparatus. The supposition that the eye-specks of Radiata may be organs of hearing seems to me, indeed, entirely set aside by the peculiar arrangement of the sensitive bulb in this genus.

The tentacles themselves are transparent threads, capable of extraordinary dilatation and contraction, although they consist exclusively of cells. When fully elongated (Plate I. Fig. 2), they appear like very thin undulating threads stretched out in a radiating manner; the middle and longer ones, however, always rise above the lateral ones, which are shorter. These bunches of tentacles seen from above or below appear like a brush of threads; but when seen in profile, it is plain that the middle ones are arched over the lateral ones, and hence the very different appearances which the animal with extended tentacles may present in different positions, when the tentacles are more or less raised, as may be judged from the appearance of Fig. 1, 2, 5, and 6, Plate I. The more the tentacles contract, the thicker they appear, and in their contractions they assume also a more undulating or curved appearance, as may be seen in Fig. 3 and 4, in the latter of which they are so much contracted as to form a short bunch of thick threads round the eye-specks; and in this contracted state the tentacles are again straighter than in a half-expanded position, as may be noticed in Plate I. Fig. 4. The dilatation or contraction of the tentacles does not take place through their whole length simultaneously, for the base may be elongated and the upper portion still contracted, or the extremity may be elongated and the base in a contracted state; or the middle portion alone may be swollen, and the base and tip elongated. And these contractions and dilatations take place in rapid succession, the tentacles being rather active; but though displaying such an activity, and such a power of dilatation and contraction, — evidently voluntary movements, — they consist wholly of cells of two different kinds; one row of large cells (Plate II. Fig. 2, 3, 4, *a*) forming the main trunk of the tentacle, the cells being either arranged in single rows, or encroaching upon each other irregularly; while much more numerous smaller cells (*b*, *b*) form a uniform coating over the whole tentacle. The contractile organ of the tentacle doubtless consists of the inner row of cells; for these change their shape considerably in the different forms of the tentacles. When fully contracted, as in Plate II. Fig. 13, they are narrowed into transverse fibres, and seem to be transverse muscles. But when elongated they are like square masses, the longitudinal diameter of which is scarcely half their transverse diameter, as in Fig. 3, *a*. Both forms, though less contracted, may be observed in Fig. 14, where the cells are broader in the elongated part, *c*, *c*, of the tentacle, and narrower in its contracted portion, *b*, *b*.

The outer coating consists of several layers of minute nucleated cells, some of which among the superficial ones are more prominent, giving the tentacle a ragged appearance under a high magnifying power. Among these cells, there are some minute ones, probably stinging cells, the nucleus of which is like an arrow-head, though I have not been able to see any of them throw out their arrows, as they do in Sarsia.

The tip of the tentacles (Plate II. Fig. 2, 4) is rounded, and there is no trace of an aperture or puncture, the whole extremity being surrounded by these small superficial cells. The last cell of the interior row, by its hemispherical form, precludes all supposition of a central canal in these tentacles. The terminations of two of these tentacles are represented in Plate II. Fig. 2, 4; and the elongation of these cells, especially as seen in Fig. 2, can leave no doubt respecting the correctness of the view I have expressed above, that this middle row is the active portion in the contractions of the tentacles. This description leaves no doubt as to the difference existing in the structure of the tentacles in different genera of the family; as we have seen in Sarsia the circular chymiferous tube radiating into the four marginal tentacles, whilst in Hippocrene there is no such communication between the two organs.

The nervous cord (Plate I. Fig. 2, 3, 4; Plate III. Fig. 1, 2, 3, 4, 5, 7, 8, 9), which extends from bud to bud, with a ganglion at the base of each bud, is not the only part of the nervous system which I have been able to trace in this animal; and though the other portions of this system differ widely from this main cord, I entertain scarcely a doubt as to their real nature. On examining minutely the walls of the vertical tubes, which are so uniform in their homogeneous structure, it is easy to discover on their inner surface one or two threads (Plate III. Fig. 5), following along the whole length of these tubes. Below the curve where the tubes bend to form the loop which is connected with the central digestive cavity, these threads combine into a plexus (Plate III. Fig. 6) of intricate fibres, from each of which arises another thread extending horizontally from one plexus to another (Plate III. Fig. 5), so that there is a circle of such threads all round the upper part of the chymiferous system, or below the centre of the gelatinous disk. This circular thread, considered in itself, may therefore be viewed as a ring encircling the upper part of the chymiferous system, forming a plexus of similar threads under the curve of each radiating tube, from which identical threads may be traced downwards to the sensitive bulbs, in which they also merge. From the middle of each upper horizontal thread, there arises a vertical thread extending downwards, and following the main course of the large inner vertical bundles of muscles.

I am not fully satisfied of the real nature of this apparatus, on account of the great difference there is between these threads and the sensitive cord of the lower margin.

Far from consisting exclusively of short ovate cells connected together in several rows, we have here very thin threads, in which the cellular appearance is almost entirely gone, excepting where they combine to form a plexus, in which some of the threads have the appearance of long caudate cells. For a time I mistook these threads for muscular fibres; but they differ from muscular fibres quite as much as they do from the main nervous cord. They are somewhat peculiar in their appearance in every respect, and from their connection with the chymiferous tubes, from the disposition of their plexuses and the circular connection between them, and from their connection with the sensitive bulbs below, I have been led to consider them as parts of the nervous system. What corroborates this view is, that I have never noticed any indication of contractions in these fibres, although contractions are so readily observed in the real muscular cells; while, on the other hand, the plexuses which they form remind us rather of the arrangement of nervous fibres than that of muscular fibres; so that, though some doubt may be entertained as to the real nature of this system, it seems more natural to consider the whole of these threads as nerves than as any thing else. I am the more disposed to consider them so, since, in Sarsia, a similar system has been traced having similar connection with the surrounding parts, bearing, perhaps, still less resemblance to the muscular system; and though I have spoken of it with some hesitation, I trust that further investigations will confirm this view. The fact that some threads arising from the plexuses below the arch of the chymiferous tubes descend along the sides of the main central digestive cavity, might be further considered as another indication of the nature of this apparatus; for muscular fibres could perform no function in connection with this cavity; the less so, as the whole cavity, as such, is capable of extensive contractions and dilatations by means of its own tissue, as described above. Finally, there is one circumstance agreeing with this view, which ought not to be overlooked, namely, that isolated threads arise from the middle of the threads extending from one plexus to another, and descend vertically from this circle along the main vertical inner bundles of muscles.

Thus the analogy between this apparatus and what has been observed in Sarsia is so complete, as to afford another argument in favor of the view I have taken of it in this animal. If this view is correct, the nervous system of Hippocrene, like that of Sarsia, would consist, 1st, of a main circular cord round the lower margin, following the circular chymiferous tube; 2d, of vertical threads following the vertical chymiferous tubes; and 3d, of a circle above, around the central digestive cavity, but at some distance from it. The main distinctive peculiarity between this system and that of Sarsia would consist in the plexuses below the arches of the radiating tube, which have not been noticed in Sarsia. This sensitive system is observed to be in so close connection with the sensitive buds, as

to justify the opinion that the dark-colored specks at the base of the tentacles are connected with the faculty which these animals distinctly possess of distinguishing light from darkness, although the connection with the nervous ganglia may not be such as to allow the formation of a distinct visual image.

The connection of the tentacles and eye-specks is closer in this animal than it is in any other of the naked-eyed Medusæ, with the exception, perhaps, of Sarsia and Slabberia, in which the eye-specks rest also upon the base of the tentacles. In Sarsia, however, the eye-speck is on the upper side of the tentacles, and the whole bud is less connected with them than it is in Hippocrene. Moreover, the tentacles being hollow in Sarsia, and in direct communication with the chymiferous tube, they must at once appear in closer connection with the chymiferous system than with the eye-specks; while in Hippocrene the tentacles, being excluded from any connection with the chymiferous system, appear connected only with the sensitive buds; so that the relations of the apparatus are considerably modified in the two types; and the fact that in Hippocrene so many eye-specks are combined in so close a manner into one and the same bud, with as many tentacles, introduces here a relation of the tentacles which is peculiar, and doubtless has reference also to their peculiar structure, in which nettling cells are so few, if, indeed, there be any proper nettling cells.

The name *superciliaris*, applied to this species, is derived from this connection of the tentacles with the eye-specks. Although this peculiarity is generic, it may be said that, in *Bougainvillia nigritella* of Forbes, there is but one tentacle to each bud, if the specimens observed were at all perfect; that there are fewer in *Bougainvillia Britannica* than in the North American species; and that in the original species, as described by Lesson, there are also fewer; so that the name of *Hippocrene superciliaris* appears quite appropriate for this species.

The above details, respecting the sensitive apparatus of so small an animal as this, will further justify the general remark already made, that there is here a much closer connection between the structure and form than is observed in any other type of the animal kingdom. Indeed, the bulbs at the four corners of the lower margin, with their movable appendages, form so prominent a feature in the appearance of these little animals, that at first sight nothing in them strikes the eye but those four dark prominences, with the main central digestive cavity; and whenever an attempt at a minute description is made, even if it be restricted to external appearances of form and color, it must include particulars which have as much reference to the anatomical structure of these animals as to their external appearance.

As in all the other Medusæ, in order to study well the arrangement of the muscular

tissue, and to be able to trace its numerous bundles in all their details, it is necessary to watch specimens in a state of great contraction, when they are about dying, or shortly after death, and even during the process of decomposition. The powerful contractile bundles on the inner surface of the gelatinous disk, to which the most powerful action during life must be ascribed, are best seen in those specimens which are rapidly dying under spasmodic contractions; — while the superficial layers outside of the gelatinous disk are even better seen when the animal is already decomposing, and the tessellated epithelium, which covers the whole surface, is either decaying or separating from the body. The cells of the lower partition are easily observed in fresh specimens during life, probably owing to the circumstance that this partition is much thinner, and consists of finer organic elements.

When examined under a powerful microscope, the superficial epithelium (Plate II. Fig. 5, 6) is found to differ in different parts of the body, and it is advisable to be familiar with it before attempting to investigate the muscular apparatus. All over the bell-shaped part of the disk, this epithelium consists of irregular polygonal cells, the outlines of which are so faint that they are hardly ever distinguished; but their existence can easily be inferred from the peculiar arrangement of their granular contents, which form a sort of mosaic (Plate II. Fig. 5), circumscribed within angular outlines, in the interior of which larger nuclei of irregular form are noticed, sometimes placed in the centre of these areolæ, sometimes nearer their outlines. The forms of these nuclei vary also, being either ovate or circular, or elongated, straight or curved, or even angular. As in the fresh state these parts are too transparent to be well distinguishable, and they only become visible in a rather advanced state of decomposition, I am not perfectly sure that this irregularity of form is entirely natural, and that the nuclei, in particular, have so diversified an appearance as is observed in the shreds which are so easily detached from the surface of the gelatinous mass during the decomposition of the body. But so much is certain, that such a ragged appearance, and this greater irregularity of the nuclei, (Plate II. Fig. 6,) are particularly observed upon the outer surface of the lower margin, where the vertical portion of the disk is turning over between the colored buds to form the transparent lower partition; and it may be that the character assigned by Mertens to his species, of having a kind of villosity around the margin, is owing to a greater irregularity of the epidermal cells in that species than in the one which I have examined. Upon the sides, however, and above the disk, as well as upon the inner surface of the main cavity, I have only noticed those more regular polygonal and flat epithelial cells, the greater number of which contain only minute granules, and occasionally among them a few larger nuclei, the whole forming a very thin film over the entire surface of the body. The

villosities mentioned as characteristic of many Medusæ may be owing to a similar epithelium differing in the form of its cells; but, as I shall have an opportunity of alluding to these cells again when speaking of the Pleurobrachia of the American shores, I will not dwell longer upon this subject now, nor make any allusion to the descriptions given by Ehrenberg of the structure of the tissues of Medusæ, as he observed it in the genus Aurelia; since his statements will better be discussed when describing the species of that family which occur in this vicinity, which will be done in the third part of this paper. The superficial bundles of contractile cells,* which are covered by this epithelium, form a remarkable network all over the external surface. They are arranged in two particular directions, the main bundles (Plate III. Fig. 7, 8, *a*, *a*; Fig. 2, *d*, *d*; Fig. 1, *e*, *f*) being vertical, and alternating with the chymiferous tubes; there being, also, circular bundles (Plate III. Fig. 1, *a*, *a*, *c*, *c*, *h*, *h*; Fig. 2, *a*, *a*) upon the surface, to which the vertical ones are attached, or with which they are at least connected. These transverse or circular fibres form first a circle (Fig. 1 and 2, *a*, *a*) above the curves of the chymiferous tubes, and another (Fig. 1, *c*, *c*) somewhat below, though this is less regular than the upper one. The upper crown or circle of muscular fibres appears like a loose net (Fig. 1, *b*, *b*) hanging over the gelatinous disk, and its position seems to favor the action of the vertical bundles, which are so connected with the circular fibres as probably to derive support in their action from their simultaneous contraction; for, from this upper ring there are muscular fibres rising upwards and arched over (*b*, *b*) towards the centre: so that, when well preserved, the muscular apparatus of this upper region of the spherical body appears as if covered with arches of muscular bundles converging upward, and resting upon a circular ring below their base. The network of arches upon the most prominent part of the summit of the disk does not exist at all in the specimen of Plate III. Fig. 2; but the circle of fibres, *a*, *a*, corresponding to that of Fig. 1, *a*, *a*, is stronger in its development, and when contracting seems to have been more deeply impressed into the gelatinous disk, than the more extensive net of muscular fibres of the specimen represented in Fig. 1. Fibres extending downwards (*d*, *d*) from this upper crown, in connection with similar transverse fibres below, form the second circle (Fig. 1, *c*, *c*), which, in its complete state, constitutes, as it were, a lower series of arches, upon which the upper rest, or to which they are suspended. From this double row of large muscular meshes arise the vertical bundles (Fig. 1, *e*; Fig. 2, *d*, *d*), which extend to the lower margin of the disk, meeting it in the middle (Fig. 1, *f*), between two sensitive buds. There are, therefore, four of these more prominent external bundles of contractile fibres;

* The whole system of contractile cells, in whatever position they occur in the body, is figured upon Plate III., in blue outlines.

but, in addition to them, smaller bundles arise, which follow, in a rather less regular arrangement (Fig. 1, *h*, *h* ; Fig. 2, *e*, *e*, *e*), the direction of the vertical tubes, and terminate (Fig. 1, *g*, *g*) above the sensitive buds.

The general position of the two specimens, Fig. 1. and Fig. 2, must explain the great difference in their appearance. In Fig. 1, which is an absolute profile, we face the interval between two vertical chymiferous tubes ; and the two other tubes, being precisely in the same position on the opposite side of the body, are not introduced at all in the drawing. In Fig. 2, on the contrary, which is slightly inclined upon its base, in order to show the lower partition, and to bring out the upper crown of fibres as a continuous ring, we face, in the middle, one of the chymiferous tubes, and have another opposite to it, also in the middle, on the other side of the body ; and at right angles with this, two other tubes, one to the right and the other to the left ; and the spaces between two vertical tubes appear everywhere foreshortened. Fig. 1 of Plate III. is nearly in the same position as Fig. 1, Plate I., with this difference, that, being absolutely in profile, the other pair of vertical tubes is not seen at all. The corresponding parts of Fig. 2 would form angles of forty-five degrees with those of Fig. 1, if projected upon the same plane.

On investigating closely the arrangement of these fibres, it is found that they do not extend in a straight course from the upper part of the sphere to its lower margin, but diverge into the arched bundles above, and in their lower course give off along their whole track similar diverging fibres. So that, properly speaking, there are four main pennate muscular bundles upon the surface, alternating with the course of the chymiferous tubes, and four smaller ones following the tubes. With the arches rising from these vertical bundles, an intimate connection is established by the more mesh-like arrangement of the upper network of muscular fibres. In their course, all these fibres remain chiefly superficial. Some of them, however, especially those of the four main vertical bundles, penetrate more or less into the gelatinous mass, though they seem nowhere to meet the corresponding bundles, which, from the inner surface, penetrate likewise into the gelatinous disk, excepting, perhaps, in the lower portion of the disk near its margin, where the gelatinous mass is much thinner, and where the superficial external bundles seem to intermingle with the deeper bundles of the inner surface.

The action of this muscular apparatus is quite obvious, both from the arrangement of the bundles, and from direct observation. The upper network of fibres contracts the upper part of the disk, while the vertical bundles shorten it, as they are strongest below, and, when combined in action with the inner bundles, they turn the lower margin inward. In this contraction, and especially when the vertical bundles are most shortened, the four marginal buds are bent inward and brought nearer together. This is particularly

the case when the lower parts of the vertical bundles of the inner and outer surface of the gelatinous disk act simultaneously; but when the outer ones alone are contracted, and especially the small bundles (Plate III. Fig. 2, *e*, *e*, *e*) above the buds are in activity, they expand the sphere again, and turn the buds outward and upward.

Though, perhaps, less complicated in their course, the inner vertical muscular bundles (Plate III. Fig. 3, 4, 7, 8, 9, *d*, *d*, *e*, *e*, *f*, *f*) which line the inner surface of the gelatinous disk are still more difficult to trace, and their action is less easily ascertained. There are four main bundles (*d*, *d*), the position of which is easily recognized. They arise from the lower surface of the gelatinous disk, above the digestive cavity, between the radiating tubes (Plate III. Fig. 9), and follow a vertical course, their fibres remaining closer together than those of the external layer; though here, also, the contractile cells diverge upwards and downwards in such a manner as to give each of the bundles somewhat the appearance of a pennate muscle. These bundles (Plate III. Fig. 3, 4, *d*, *d*) terminate below the margin midway between the sensitive buds. Their fibres penetrate more deeply into the gelatinous mass, especially below, where they meet the superficial bundles, and intermingle with them (Plate III. Fig. 8, *d*, *a*, *d*, *a*, *d*, *a*), under acute angles, *a* being the superficial, and *d* the inner vertical bundles. Of course, seen in profile (Fig. 3, 4), these bundles follow the curve of the gelatinous disk, which is the same as that so plainly shown by the chymiferous tubes. When seen from above (Fig. 7, 9), it might easily appear as if there were several bundles of muscles placed one above the other; for in this position, the arch which the bundle forms from the centre towards the lower margin is so foreshortened, that its upper portion is seen separately from the lateral portion; and as this is straighter, the appearance is as if a stronger muscle were placed outside of the feebler one, which seems to be nearer the digestive cavity. But a vertical view (Fig. 3, 4) will leave no doubt about the continuity of these muscles, and easily show that the appearance noticed from above is that which a vertical pennate arch would present if it were drawn so that both the arched and the vertical part could be seen projected upon the same plane (Fig. 7, *d*). Then the arched part passing into the vertical stem would be foreshortened so as to appear very thin, and the long vertical branch itself would appear very strong, from the many branching fibres thus accumulated upon each other in the vertical view. In Fig. 7, *d*, where these main bundles are thus foreshortened, they appear like anchors, owing to the particular focus under which they were drawn; when, in addition to the complications already mentioned, the pennate arrangement of the fibres appeared most prominent, and formed, as it were, the two curved arms of the anchor.

Alternating with these main bundles, there are eight others (Plate III. Fig. 3, 4, 7,

8, 9, *e*, *e*, *f*, *f*), which, however, are much less powerful, and are placed half-way between the main bundles and the chymiferous tubes on both sides. These bundles follow the same course as the four others, and present the same relative disposition of their fibres, but in such a reduced scale as not to be always apparent, and hardly ever to appear as continuous vertical pillars of contractile fibres. Their existence, however, cannot be doubted for a moment in certain states of contraction of the inner surface, when the muscular vertical bundles are shortened in such a manner as to form with their pennate threads undulating lines curved in opposite directions, which, in a view from above or below, intersect each other completely. Such a view is given in Plate III. Fig. 7, 8, 9, where the main bundles, with their lateral fibrillæ, are curved inwards, and the eight secondary bundles outwards, meeting, in this case, similar curves formed by the strong bundles. The greatest difficulty is experienced in forming correct ideas of all these undulating lines intersecting each other, unless one has traced them in all possible degrees of contraction. When the body is slightly contracted, and its circular form is still preserved, as in Plate I. Fig. 3, 4, the intersecting lines are only those of the four main bundles marked out upon the outlines of the gelatinous mass. But as the contraction increases, as seen in Plate III. Fig. 8, the undulating lines of the outer surface are seen to correspond to the inner ones, and the eight secondary bundles coming into play, instead of four arched lines there are now twelve, intersecting each other; and in Plate III. Fig. 7, the contraction being most powerful, each of these curves forms a narrow arch, and all these arches intersect each other in the same way, to form now an eight-rayed star instead of a more or less quadrangular figure, the chymiferous tubes alternating with the four main muscles to form the curves bent inwards, and the eight muscular secondary bundles arched outside to form the eight prominent angles of the figure, the undulations of the external surface corresponding, even in that state, to those of the inner surface. The correspondence of the external and the internal vertical muscles is remarkably well shown in Plate III. Fig. 7, 8, where *a*, the main external vertical bundles, correspond to *d*, the main internal vertical bundles, and *e* and *f*, the secondary internal vertical bundles, correspond to less regular secondary external bundles, *b*, *b*.

The third chief layer of contractile cells (Plate III. Fig. 3, 4, *i*, *i*) lines the main cavity of the body, and presents a circular arrangement, so that, in its chief disposition, this system crosses the vertical bundles everywhere at right angles. The existence of a continuous muscular coat over the whole inner surface of the lower side of the disk would hardly be suspected, unless upon the closest examination, and a careful selection of suitable specimens. But whenever its constituent parts are in such a state of contraction as to render them

visible at all, they are very distinct. This layer lines the whole cavity between the main digestive sac and the lower partition, covering the four radiating chymiferous tubes, and being itself covered by a very thin epithelium, not always easily seen upon every point; the existence of which, however, is frequently revealed by the polygonal flat cells which are detached from its surface. This muscular layer is not a simple coat lining uniformly the whole cavity of the body. On the contrary, it consists properly of four sets of transverse bundles, extending from one chymiferous tube to another; so that it may be said that there are four walls of horizontal contractile fibres, beginning above the main digestive cavity, curving over between the arches of the chymiferous tubes, then extending downwards to the horizontal circular tube, and meeting for their whole length upon the inner surface of the vertical tubes. Seen from above, these circular fibres appear like a ring encircling the upper part of the central digestive cavity. This ring has a double outline, as may be seen in Fig. 7, *b*, *c*; Fig. 9, *b*, *c*; and Fig. 4, *b*, *c*. Whether this double contour, however, arises from the relation between the circular muscles and the chymiferous tubes, or whether there is a double layer of muscular fibres in the upper part of the disk, or whether the double outline arises from the curve of that part of the inner surface, bringing in each particular position certain fibres more prominently into view, I have not been able to ascertain. Though in the main horizontal, or transverse, these fibres are more or less arched upwards and downwards, or outwards. They are arched upwards above between the arches of the chymiferous tubes. They are arched outwards about the middle of the bell-shaped disk, and they are somewhat arched downwards nearer to the lower margin. The fact of these circular horizontal fibres meeting upon the inner surface of the vertical tubes is important, inasmuch as it is one argument more against the supposition, that the vertical threads which accompany the vertical tubes in their regular course, and which I have ascribed to the nervous system, are of a muscular nature. Moreover, it is easy to see that, while the former are either in a contracted or relaxed state, the latter always present the same appearance.

The natural function of these circular fibres is to reduce the capacity of the central cavity, and hence, when assisting the vertical fibres, to contribute to locomotion. But they may also be subservient to the process of circulation, by the traction they exert upon the radiating tubes. A slight contraction may also contribute to renew the water in contact with that inner surface. The fact, that they line so uniformly the whole central cavity of the body, would lead to such a supposition. Indeed, Medusæ whose body is so little active and almost closed as that of Hippocrene need some special means besides the locomotive movements to maintain a regular exchange between the water within and the water without the cavity. I have so often observed the lower of these

fibres contracting more powerfully than the upper ones, that I hardly entertain a doubt with respect to their coöperation in the locomotive process. But, had not this system a particular function, I hardly see why it should be so well developed in the upper part of the inner cavity, which is hardly liable to great changes arising from muscular action. The fact that these horizontal or circular fibres line the arched cavity gives to the fibres themselves, when seen in different positions, such various aspects, that here again it is very difficult to form correct views of the whole system; especially so, as very often the curves of the horizontal fibres coincide with the curves of the fibres diverging from the pennate vertical muscular bundles, in such a manner as to cover each other in the perspective, or to be easily mistaken one for the other. And, in such views, the horizontal circular fibres contribute to strengthen the appearance of the intersecting undulating lines formed by the vertical bundles already described, especially when seen from above (Plate III. Fig. 9, *i*). But in profile views, the fibres belonging to the circular system are readily distinguished from the fibres belonging to the vertical bundles, even when they assume an arched appearance, by the circumstance that the former are attached to the chymiferous tubes, as seen in Fig. 3 and 4, while the latter alternate with these tubes. About the chymiferous tubes, there are, however, more or less distinct threads, especially upon the inner surface, which seem to intersect the horizontal circular system, and nevertheless neither to belong to it nor to the vertical muscles. They rise (Fig. 3, 4, *g*, *g*) chiefly from the middle of the height of the main cavity, and diverge towards the main vertical muscles, following, however, the form of the main cavity, upon the inner surface of which they are appressed, and intersecting under various angles both transverse and vertical fibres. But for these fibres, I should not have the slightest doubt respecting the real nature of those other fibres which I have ascribed to the nervous system; and had I noticed a plexus-like crossing of these fibres with each other, I should have given up the idea that the meshes of fibres under the chymiferous arches are sensitive plexuses. But here the oblique fibres intersect fibres of other systems, and do not intersect each other, as in the plexuses described above.

In addition to the difficulties depending upon the nature of the subject itself, which we experience in tracing these muscular bundles, there is another difficulty, arising from the position in which we trace them. There being four radiating tubes, the whole animal assumes a very different appearance, according to the position in which it is viewed. When we look at it in such a position that two tubes are placed upon one side and two upon the other, as in Plates I. and III. Fig. 1, we face the flat side of a broad surface stretching between the two tubes nearest to us in the profile. But if we place the animal in such a position as to have right and left a single tube, and one upon the middle

line in front covering another behind, we at once place the plane between the tubes in an oblique position, and every thing in a different light. And these two positions, in which it is, after all, easiest to study the parts of the animal, may be still further complicated by introducing intermediate positions; such, for instance, as that represented in Plate III. Fig. 5; and the difficulties are beyond the patience of the observer, if, in addition to these numerous front positions, the difficulties of oblique positions are introduced, in which partial views from above are combined with partial profiles. I have spent weeks in attempting to make myself familiar with these different views, and if I were not conscious of having overcome most of the difficulties connected with the investigation, I should by no means be so positive about the direction of the fibres of the muscular system in the different layers described above.

The region about the upper part of the digestive cavity presents such a complication of different parts brought in connection with each other, that it is very difficult to form correct ideas of them, and still more to appreciate their forms and connections, when seen either from above or in profile. There is, especially, one point which puzzled me for a long time, — the fact that, in the upper part of the arches of the vertical tubes, all the outlines seem double. This is partly owing to the circumstance that the mere form of the main cavity of the body gives rise, under different intersections of light, to the formation of outlines which have no real existence, and that these outlines, seen across the gelatinous mass from the two sides, are reflected upon each other. But after this difficulty has been overcome, and we see the structures in their true simple character, there is still a difficult point in defining the outlines of the upper transverse muscular bundles stretching between the arches of the chymiferous tubes, and in distinguishing them from the circular nervous thread, which connects the nervous plexuses under the arches of the chymiferous tubes; for here, again, the muscular fibres run so nearly in the same direction as the nervous thread, that, but for the contractility of the one and the steadiness of the other, they would be easily mistaken; and I am not fully sure that, even after alluding to this difficulty, they will always be correctly seen, especially when examined from above. A comparison of Fig. 4 and 5 of Plate III., in which the nervous system (Fig. 5) is represented in a position of the animal almost identical with that in which we see the system of circular muscular fibres, Fig. 4, will at once give an idea of the amount of difficulty there must be in identifying these various parts, especially when it is remembered, that both the nervous and muscular systems have to be studied through the thickness of the gelatinous disk. Seen in absolute profile, the difference is more obvious, for here the muscular bundles are so arched as to contrast with the nervous fibres stretching across the same space.

There is another point which requires particular attention. Owing to the thickness of the chymiferous tubes, the transverse muscular coat of the inner surface is somewhat separated from the inner surface of the gelatinous disk near the tubes themselves, and these spaces left between the disk and the layer of muscles on the sides of the chymiferous tubes give rise to a double contour in the uppermost part of the arch, which, in addition to the difficulty already mentioned, is likely to create misapprehension in estimating the appearances presented by the parts meeting about the centre of the disk under the gelatinous mass.* Indeed, seen from above, it would seem as if there were a distinct circle of peculiar organs, or rather of peculiar tissue, the periphery of which would inclose the space to which the prominent corners of the digestive cavity reach, as seen in Plate III. Fig. 7 and 9, and also Plate I. Fig. 3. The fallacy of this outline is further increased by the appearance of the four main bundles of vertical muscles, which arise, as it were, from those of the circle, (Plate III. Fig. 9,) and stretch downwards. The outline of these circular fibres is sometimes made very prominent when the opening of the lower partition is reduced by contraction, as in Fig. 7. Both circles, however, are more distinct and farther apart when the outline of the lower partition is in a state of relaxation, as in Fig. 9. This outer circle, as seen from above, is a real outline. It is the free margin of the lower partition, *k*, which is as definite as the outline of the lower circular tube, *o*, or the nervous cord, *m*, which in such views are all brought together in focus; but the middle upper circle has no more reality than the undulating lines *d*, *e*, *f*, seen outside of the chymiferous tubes, in Fig. 7, 8, 9, and 4, — which are only the foreshortened outlines of the undulations produced by the contraction of the muscular system, — with this difference, that the upper circle is formed both by the muscular coating, and by the influence which the prominent gelatinous knob in the centre has in causing an outline to appear round its base, where it bends over into the arch of the sides. But the double outline between the muscular coating and the arches of the chymiferous tube is hardly ever noticed from above; neither is it noticed in the complete profile; but it is constantly and distinctly seen in a three-quarter view (Plate III. Fig. 2, and also Fig. 4); and I must confess that I never met with more perplexing difficulties than those I experienced in satisfying myself of the real nature of what so clearly seemed a structure, which always vanished under certain influences of light, while it was so plain under others.

The fourth muscular system is extended between the four sensitive bulbs within the lower margin. Plate I. Fig. 2, 3, and also Plate III. Fig. 9, *k*, and Fig. 2, *f*, *f*, give an excellent view of it, in its general outline, though no structure could be drawn with

* Upon this particular point, compare also another remark already introduced above, when describing the circular fibres.

this magnifying power. But from those figures, (and, if the attention is once called to it, Fig. 1 and 4 of Plate I. will show the same,) it may be noticed that there is a partition stretching inwards from the lower margin, terminating with a free edge, through which a broad and free passage is left between the main cavity of the body and the surrounding medium. This partition, which thus almost closes the main digestive cavity and its contents from direct communication with the surrounding medium, is highly movable and contractile, and indeed consists chiefly of muscular fibres, covered with a very thin epithelium. It is not a mere prolongation of the lower edge of the disk, nor are its contractile fibres a part of the inner circular system of bundles; for it arises from the inner margin of the circular chymiferous tube, and the main nervous cord. It is not gelatinous, as the disk, and though very clear cells surround and protect the chymiferous tubes and the nervous cord of the lower margin, and thicken its walls, nothing of the clear jelly-like substance is seen within the horizontal partition. It is made up, outside, of epithelial cells, and within chiefly of a thick layer of circular muscular fibres, with which alternate some few radiating fibres, which cross the former at right angles, and are more numerous about the eye-specks. In Plate II. Fig. 14, *g*, *g*, a portion of this partition near the sensitive bundle is represented, with its circular and radiating fibres. In Plate III. Fig. 12, the linear arrangement of the circular fibres is shown, without their natural connection with the radiating fibres. And in Fig. 14 of the same plate, the radiating fibres, *d*, alone are represented, to show how they converge towards the main bulb. In Fig. 15, again, a portion of the lower margin is figured, to show the connection between the sensitive cord and the circular chymiferous tube, *b*, *c*, the thick wall of the body, *d*, and the horizontal partition, *a*. The fragment here represented is seen from outside, laid flat. The natural connection of all these parts may be better ascertained from Plate II. Fig. 17, where *d*, *d*, represent the vertical tubes above the bulbs; *a*, *a*, the circular tube; *b*, *b*, the nervous cord; *c*, *c*, the horizontal partition; *f*, fibres of the main vertical inner bundles; and *e*, the outline of the external surface of the wall of the body. The arrangement of the fibres of the partition is very much the same as that of the contractile fibres of the iris; and its operation also the same, inasmuch as this main orifice is alternately widely opened or closely shut.

These muscular fibres cannot be referred to the same system as that which lines the main cavity, for they are continuous all round the partition, and not attached in any point of their circuit to other organs, but support each other in their connection. The contraction of these muscular fibres, however, may be combined in such a manner with the contractions of the other muscular bundles, as either to protrude the partition between the sensitive bundles outwards in the shape of a beak, or to retract it into the shape of a

funnel. I suppose these very great changes in its form (for it is generally stretched horizontally) are brought about, in a great measure, by the action of the muscular fibres which arise from the chymiferous tubes, and run obliquely downwards. (Plate III. Fig. 3, *g g*, Fig. 4, *g*, *g*, *h*.)

The appearance of the muscular tissue in this animal, as studied under high magnifying powers, varies somewhat in different parts of the body. Wherever the tissue can most easily be traced in its intimate structure, scarcely a doubt can be left that the muscular fibres are elongated cells. Indeed, in the horizontal partition, it is as plain as possible. The whole tissue appears like layers of elongated, or rather caudate cells, with one end blunter than the other; and the nucleus near the larger end now and then contains a nucleolus. These cells are in such juxtaposition as their heterogeneous form requires to fill the whole space, the blunt end being sometimes in one direction, and sometimes in the opposite direction, and the attenuated part of the cells packed more or less closely together, so as to leave no empty space between, as is seen in Plate III. Fig. 11, or in Fig. 10, where they are more fully metamorphosed. These latter cells appear almost entirely thread-like, though the nuclei are still preserved. In the large vertical bundles, however, the approach to ordinary muscular fibres is nearest, inasmuch as few nuclei remain between the threads. But one circumstance distinguishes such muscles completely from any of the muscular structures of higher animals: there is nowhere any indication of transverse striæ upon the fibres; there are no sarcous elements, nothing like that reticulated structure of true muscles which has been observed in the higher animals. The condition of the voluntary contractile system of Medusæ comes nearest to that of the unstriated muscles of higher animals. Indeed the aspect of the true voluntary muscles of Hippocrene almost reminds us of the figures of unstriated muscle given by Kölliker.

IDEAL SECTIONS.

Though the figures to which I am about to refer cannot claim the merit of extreme precision, they will at least contribute somewhat to an understanding of the results to which I have arrived respecting the structure of this animal. I have therefore thought it useful to introduce them, in order that all the parts, which I have above described in their natural relations, may be thus represented more definitely than they are really seen in nature.

Plate VIII. Fig. 1, gives merely an outline of the gelatinous disk in a vertical section. It will be noticed here, that its inner lower surface, instead of being simply arched, has a central rounded prominence, *a*; that the thickest part of the vault, *b*, is above the main cavity; and that the lateral walls, *c*, gradually taper downward into a narrow

edge. The difference between the form of Hippocrene and that of Sarsia will be particularly obvious, when this figure is contrasted with Fig. 4, which represents the disk of Sarsia in a similar section; where it is seen, that the lower surface of the vault, *a*, is uniformly arched, without a central projection; that the thicker portion of the vault, *b*, is much thinner than in Hippocrene; and that the lateral walls, *c*, are comparatively higher

Fig. 2, 3, present two views in vertical section; in one of which, Fig. 2, the section passes through the main cavity, across its flat walls, in such a manner as to leave two tubes in each half wholly untouched, which thus follow, in their natural position, the inner surface of the main cavity; and these tubes are represented in the same position in which they also appear in the transverse sections, Fig. 7 and 8. In the other view, as given in Fig. 3, the section passes through the main cavity, in such a manner as to cut through the angles of that cavity, and pass through two opposite tubes, which appear on the sides of the figure. One of the two other tubes, which are placed at right angles with the former, is seen in its natural position, untouched, rising behind the middle of the main digestive cavity, and descending along the wall below the mouth. In both figures, the main digestive cavity is cut into halves; but in Fig. 2 it appears narrower, as the cut passes through its shorter diameter, without cutting into the projecting angle, and only the openings leading to the vertical tubes are seen, as the tubes themselves rest against the walls, which have remained entire; while in Fig. 3, the section passing through the tubes themselves, their cavity is laid open in direct continuity with the main digestive sac, the greatest width of which is here laid open. The inner vertical muscular bundles (Fig. 2, *a*), as well as the outer vertical ones (Fig. 2, *b*), and the transverse bundles (Fig. 3, *c*), as well as the horizontal partition (*k*, *k*, *k*, *k*), are distinctly shown, the relative size of the fibres being, however, exaggerated, in order to bring more fully into view the different systems. The nervous system is represented by simple dots (Fig. 2); *d*, *d*, being the transverse section of the main circular cord, and *e*, *e*, the transverse section of the upper circular thread. In Fig. 3, however, the vertical nervous threads, *f*, *f*, and the plexus, *g*, *g*, under the arch of the vertical chymiferous tubes, may be followed along their whole course. The eye-specks, with the tentacles, are also introduced (Fig. 3, *h*, *h*); but the tentacles are cut short near the base in order not to complicate the figure too much. The circular chymiferous tubes (*i*, *i*, *i*, *i*) appear in the two figures in a transverse section, being in Fig. 3 somewhat wider at the base of the eye-speck. Fig. 5 and 6 represent precisely the same parts in Sarsia, with corresponding letters, so that a comparison of the figures will best exemplify the difference between the two genera.

Fig. 7 represents a transverse section just above the main digestive cavity; and Fig. 8 represents another transverse section just above the eye-specks, where the transverse

diameter of the body is smallest; the dotted circle outside indicating the greatest periphery of the animal. In Fig. 8, the vertical tubes are intersected in the lower part of their vertical branches; but in Fig. 7, through both the ascending and the descending branch, just above the main digestive cavity. In this way, the true relations between all parts are easily appreciated.

In Fig. 7 we see the circular muscular fibres (*a*) and all the vertical bundles cut transversely, the external (*b*) as well as the internal (*c*), the main bundles as well as the secondary ones.

In Fig. 8, instead of the main digestive cavity, we have in the centre the lower partition (*a*), the main nervous cord (*b*), the circular chymiferous tube (*c*), and the four bulbs (*d*), fully displayed. But the sections of the vertical muscular bundles (*e*, *e*) are much smaller, and the lateral walls are much thinner.

Fig. 9 and 10 correspond to Fig. 7 and 8, respectively; showing the same parts under the corresponding letters, with this difference, however, that, the upper arch of the chymiferous tube being uniform in Sarsia, the section which passes through the main digestive cavity lays open, for a considerable distance, the inner cavity of the tubes themselves, as well as that of the digestive sac; if it had been made a little lower, the whole central cavity would have been removed, and only one section across the vertical tubes would have been shown, and not two, as in Hippocrene, the tubes forming no cross in their upper region. Again, in Fig. 10, when contrasted with Fig. 8, we see, in the centre, a transverse section of the proboscis, as this hangs almost constantly lower down than the lower outline of the main mass of the body; but otherwise, all parts are precisely identical.

The alternate generation of Hippocrene has not yet been traced directly, so that I am unable to say whether this species originates from a Hydroid Polyp, similar to Corynæ, or from one of the new genera described by Sars; or whether the suggestion which I made in my Lectures on Embryology, that they arise from Tubularia, is a correct view of the case. From the greater number of tentacles in Hippocrene, from their more prominent connection with the margin of the bell-shaped disk, and from the numerous fringes around the opening of the mouth, I was led to suppose that the Tubulariæ are really the polypidoms from which Hippocrenæ are produced. I feel still more inclined to consider them so, as specimens of Hippocrene are scarce, when those of Tubularia are very abundant; and for the reason that the reverse is the fact with Sarsia and Coryna, I should say that we are justified in considering them as sustaining that relation to each other. For those animals which pass through alternate generations in the course of their development will prosper either in one or the other state; and the one which is the most prominent feature in their existence brings, as a natural consequence, the less frequent

occurrence of the other state; just as those caterpillars which live long in the caterpillar state are more frequently met with than the moth which they produce, the duration of whose life is short; and *vice versâ*, the butterflies, which live nearly throughout the year, and spend a few weeks only in the caterpillar state, are more often seen in a perfect condition, while the caterpillars are of rare occurrence.

Another difficulty would seem to be more serious, namely, that there are at least two species of Tubularia, very different from each other, found on these shores; while only one Hippocrene has as yet been noticed. I am well aware that more than two species of Tubularia have been described, but I should not be in the least surprised, if all the branching and simple varieties were mere forms of two distinct types, one of which has a large crown, and the other a small one, — one a prominent inner tube, and the other a shorter one. The fact that the proboscis in Tubularia is fringed around its opening is greatly in favor of its being the alternate generation of Hippocrene, in which the mouth is also adorned with bunches of fringed or branched tentacles. But the difficulty of more species would be unanswerable, if we could be positive that we know all the species of Medusæ occurring along these shores. That this, however, is by no means the case, I ascertained during the last summer, when I found (in localities where the two types of Tubularia occur simultaneously) no less than four species of Medusæ belonging to four different genera, which had never been noticed before on the coasts of Massachusetts;* and one of these new species is closely allied to Hippocrene; though, from the peculiarities in its tentacles and eye-specks, I am inclined to consider it a peculiar genus, of which I shall say a few words at the close.

I have had some hope of raising the polypidom type of Hippocrene from eggs of this species, but have been unsuccessful in this respect, though several specimens I had preserved in glass jars have laid their eggs in captivity. But these eggs are so minute, that with all possible care, and all attention bestowed upon them, I have been unable to preserve them so as to watch their growth. The eggs are so minute that it requires a certain magnifying power even to see them, and to watch them in the water after they have been scattered about is almost impossible, as the isolated eggs completely escape the power of the naked eye.

* For the opportunity of observing so many new marine animals, I am indebted to the liberality of Professor A. D. Bache, Superintendent of the U. S. Coast Survey, who has repeatedly allowed me to avail myself of the surveying vessels under the command of Lieutenant Charles H. Davis, for the purpose of scientific investigations. I cannot allow this opportunity to pass, without acknowledging publicly my gratitude for this liberality, and returning my most sincere thanks to Lieutenant Davis for the kindness with which he has constantly assisted me in my researches.

My observations upon the developement of Hippocrene have therefore been limited entirely to the investigation of the eggs, as they appear during the time they remain connected with the maternal body. The eggs are developed in the outer layer of the walls of the main digestive cavity, under the layer of epithelium which covers that organ. They are imbedded between the transparent cells of the outer parenchyma, and appear at first as minute transparent vesicles, which grow rapidly, and increase the bulk of the central mass to such a degree as to change vastly its form (Plate II. Fig. 20, *c*, *c*, *c*, *c*, as seen from above). As soon as the eggs are ripe and ready to be laid, they assume (when seen from below) the appearance of four bunches of grapes united at their wider base, with the smaller end turned outwards (Plate II. Fig. 23, *f*, *f*, *f*). Fig. 4 of Plate I. represents a specimen with mature eggs, seen from above; while Fig. 1, 2, and 3, represent specimens deprived of eggs. After the eggs have been laid, the surface to which they adhered has a furrowed appearance (Plate II. Fig. 18); it seems folded, and isolated eggs may be seen still adhering in little depressions. These folds and depressions may be considered as a kind of *corpora lutea* left in a tissue containing no vessels, and assuming, therefore, a very peculiar appearance.

The eggs themselves, when mature, show distinctly a large germinative vesicle, more or less central, surrounded by a considerable quantity of yolk, consisting of granular cellular tissue of a yellowish-white color, inclosed in the vitelline membrane. Within the large germinative vesicle there is a single transparent germinative spot. Between the earliest formation of the egg and this state of development, in which the yolk has not yet undergone further changes preparatory to the formation of the germ, there are in the same ovary eggs of very different degrees of maturity, from the most minute transparent cells, already mentioned, up to larger and larger vesicles, with a more or less transparent yolk, and a distinct germinative vesicle and germinative spot. But the eggs do not seem to be all laid in the same state of development, for I have observed some still adhering to the central cavity, in which the yolk had assumed on its surface a mammillated appearance, forming a kind of mulberry-like body, probably the earliest stage of development of the germ; while others were laid before they had undergone any such changes. The fact of this inequality of development in the growth of the eggs in Hippocrene seems to be in accordance with the facts observed by Professor Forbes in the genus Lizzia, which is closely allied to Hippocrene, where real buds grow from the ovary, and are developed to a considerable degree before separating from the maternal body. In Hippocrene, however, I have never seen real buds arise in that way, but have uniformly seen the eggs cast before they had lost their spherical form.

The new genus of naked-eyed Medusæ to which I have alluded, and which resembles Hippocrene so closely, differs from it in having a more movable and bottle-shaped central digestive cavity, which may be more or less protruded from the main cavity of the body, and is not so persistent in its form as that of Hippocrene. The tentacles are arranged, as in Hippocrene, in four bunches, with eye-specks at their base; but there are two of these eye-specks supported upon two distinct stalks, rising above the others and above the tentacles, similar in appearance to the protruding eyes of a snail. Unfortunately, I was unable to have correct drawings of this animal made at the time when it was first observed. I subjoin a mere wood-cut, from a drawing made hastily at the time, by my son, Master Alex. Agassiz. The specimens were caught in the harbour of Nantucket, in June, 1849. For the genus I propose the name of Nemopsis, and shall call the species *N. Bachei.*

TIAROPSIS.

In its general outlines, the species upon which this genus rests is very plain. It has a hemispherical body of perfectly regular form, but of a very elegant appearance in its beautiful simplicity. Imagine a convex disk of transparent jelly, with a slight bluish milky tint, from less than half an inch to nearly an inch in diameter, somewhat like a deep watch-glass, with its margin fringed all round, and with the centre somewhat thicker, having a short proboscis in the middle, spreading into fringed lobes, from the upper side of which arise four tubes, diverging at right angles to meet the margin, with an elliptic or fusiform flattened swelling about the middle of their course, and eight deep black specks along the margin between the marginal tentacles, at the base of each of which there is a small black speck, and you will have as correct an image of the general appearance of this pretty little Medusa as a first impression may leave. When it is in motion, however, its form varies to a considerable extent, by the contraction of the muscles. When relaxed (Plate VI. Fig. 1), it is a very flat, saucer-like convex disk. When contracted (Plate VI. Fig. 2, 3, and 4), it assumes a more hemispherical shape, and when highly contracted, approaches nearer and nearer to a globular form. But in its state of high contraction (Plate VI. Fig. 6), the peripheric part of the disk is more or less detached from the central part by the stronger contraction of a muscular ring, forming a circle on the outer surface of the body above the tentacles. These forms pass gradually from one into the other: the margin may even be spread, and the centre so contracted as to give it a more globular form, when the outline of the animal assumes rather the shape of a church-bell. The circular outline of the whole body may also be somewhat modified, and assume a subquadrate appearance (Plate VI.

Fig. 7), but never to the extent which is observed naturally in Staurophora, unless in very powerful contractions after death, or during the violent spasmodic contractions preceding death, when specimens are sometimes seen to assume nearly the form of a four-rayed star (Plate VI. Fig. 8) when viewed from below, with a rounded disk above.

The movements of the animal are very graceful, and rather sustained. They are not, however, so powerful and energetic as in Sarsia, nor so abrupt and by starts as those of Hippocrene. It proceeds onwards or moves in all directions, upwards, downwards, or sideways, or changes its course in a direction opposite to that in which it was previously moving; and in all these evolutions it performs its movements in a very gentle and quiet way, full of grace and elegance, and has nothing of the quick, brisk, and I may say violent, movement which is so characteristic of Sarsia, — displaying in this mode of locomotion the difference of temperament there is between the species of the two genera, and indicating milder habits, and a less rapacious or voracious disposition.

Indeed, Tiaropsides are never seen to attack Medusæ larger than themselves. They rather feed on smaller prey, as very young Ephyræ, or on small particles of decaying animal matter. The shortness of their proboscis, and the lobed form of its margin, are in accordance with the indications derived from their way of moving. They seem rather adapted to suck their prey, than to take strong hold of it with a powerful proboscis, as is the case in Sarsia. They appear always in large numbers, gently sailing about, hither and thither, in the midst of the waters, with slight indications of activity, and are frequently chased by Sarsia, which prey largely upon them.

These little animals are the free Medusa state of animals very common on these shores, which have been long known under the name of Campanularia, and which are supposed to belong to the class of Polypi. But as I have been able to trace the whole transformation of successive generations of these animals, I shall in another part of this paper give a complete history of their development, limiting myself here to describing the particulars of their structure, in the full-grown condition of the Medusa state.

Like all other naked-eyed Medusæ, Tiaropsis has a gelatinous disk with a central digestive cavity, from which arise chymiferous tubes (Plate VI. Fig. 5), diverging at right angles towards the margin, where they unite with the circular tube extending all round the lower outline of the body along the base of the tentacles. This circular tube communicates freely with the vertical ones, and through these with the central cavity, so that chyme, which is elaborated in the main central cavity, is circulated to and fro in these tubes, without, however, passing into the tentacles, which are not hollow, as in Sarsia, but solid, as in Staurophora and Hippocrene. Within the margin, on the inner side of the circular tube, a thin nervous cord is observed, as in the other genera of this family.

The peculiarity in the tentacles of this genus (Plate VI. Fig. 3, 4, and 5) consists in their regular distribution all round the lower margin of the body, having each a small eye-speck at the base; but in addition to these, there are eight larger eye-specks (Plate VI. Fig. 3, 4, and 5, *c*, *c*), without tentacles, placed in the same row with the tentacles, but somewhat lower, and at equal distances from each other, being indeed, morphologically speaking, of the same kind as the smaller ones, only more individualized as organs of sense, standing out more prominently, and probably performing more decided visual functions, than the little black specks at the base of the tentacles. These eight ocelli, though in reality very small, nevertheless readily strike the attention of the observer from their very deep black color. They are placed (Plate VI. Fig. 5) in pairs between the radiating tubes, and rather near these tubes, so that the distance between them all is equal, there being none upon the tubes themselves.

The tentacles around the margin are so short, as to appear like an elegant little fringe all around. But the four radiating tubes are a striking feature in the appearance of these animals, not so much from their dimensions and prominence, as from the fact, that the ovaries or spermaries (Plate VI. Fig. 5, *a*, *a*, and Fig. 9, *c*, *c*) are attached to the middle of these tubes, in the form of elongated ribbons of a dark color, which bring out the position of the radiating tubes much more distinctly, and almost force the eye to notice the slender tubes (*b*, *b*) with which they are connected. Finally, the central proboscis (Plate VI. Fig. 3, 4, and 5, *e*), with its fringes (*i*, *i*), also attracts attention; and the whole animal may very well be compared to a diminutive umbrella, with four spreading rays, thicker in the middle, a very short handle in the centre, and light, delicate fringes with dark specks around the margin, swimming gently in the water, and moving voluntarily, with much grace, in all directions.

With regard to all the prominent features of its structure, Tiaropsis stands about intermediate between Sarsia and Hippocrene, especially in the arrangement of the alimentary system, and the fringes of the margin in their connection with the eye-specks. The proboscis (Plate VI. Fig. 9, *a*) is short; the central cavity is small, but it is not so completely shut up and permanent in its form as in Hippocrene, nor so movable and protractile and retractile as in Sarsia. It may expand (Fig. 12), unfold its fringes (Fig. 9, *b*), stretch itself in one direction or the other, adapt its outline to the bodies upon which it feeds, and display a great range in its movements and in the changes of form and extension which it successively assumes, without, in that respect, approximating in any measure to the extraordinary power of expansion and contraction which is so characteristic of the proboscis of Sarsia. If we could imagine the central cavity of Hippocrene (Plate I. Fig. 1) to be exceedingly movable, instead of preserving its fixed quadrangular form, and the lobe of its margin to be regularly undulat-

ing, more deeply cleft in sinuous outlines, instead of the regular dichotomal division which characterizes it; or if we could conceive the proboscis of Sarsia (Plate IV. Fig. 1) to be contracted within the main cavity of the gelatinous bell, to be shortened to about one fourth of the diameter of the main gelatinous disk, somewhat more than is represented in Plate V. Fig. 10, to be split about the opening, and the power of motion to be limited within this margin, rather than to extend to the whole cavity; then it would be seen how closely indeed these three genera resemble each other in the structure of their alimentary apparatus, notwithstanding the striking difference in its outlines. But it is important that such comparisons should be made, in order that we may fully understand that there is no difference — no organic difference — between those Medusæ which have a long proboscis, and those which have apparently none. This is the more important, as various authors have classified the Medusæ, and subdivided them upon the ground of the existence or absence of a proboscis; but we shall presently see that in such classifications Staurophora, Berenice, and other genera are entirely removed from the vicinity of Sarsia, Thaumantias, and Tiaropsis, when in reality they should be placed side by side, as I may show hereafter.

I have failed to trace nettling cells around the margin of the oral fringes and upon the tentacles of Tiaropsis, though I hardly doubt that they exist, with all the complication of the various kinds of lassos characteristic of all the appendages employed by these animals in securing their prey.

The main central cavity of the digestive apparatus is very small (Plate VI. Fig. 9, seen in profile, 10, seen from below, and 11, seen from above). It is a rather narrow funnel, divided into four tubes, radiating at right angles along the inner surface of the gelatinous disk, towards the margin of the animal. These tubes are funnel-shaped (Fig. 9, *d*) where they arise from the central cavity, but are soon narrowed into uniform tubes, extending without modification to the margin of the disk. The relations between these four chymiferous tubes and the circular tube of the lower margin of the gelatinous disk are precisely identical in the genera Tiaropsis, Sarsia, and Hippocrene. There is the most free communication between them. The chyme is circulated to and fro from the central cavity into the radiating tubes, and from these into the circular tube, and *vice versâ*. There is, however, this marked difference between the three genera, that in Sarsia there is but one eye-speck with one large tentacle arising from the junction of each radiating tube with the circular tube; in Hippocrene there are bunches of tentacles with eye-specks arising from the same position; while in Tiaropsis the tentacles are uniformly arranged all round the disk, without the free spaces existing in both the former, in which the margins between the radiating

tubes are entirely destitute of either eye-specks or tentacles, these being altogether limited to the junction of the radiating tubes with the circular tube. In Tiaropsis, however, the tentacles and eye-specks are not only uniformly distributed along the whole margin without any prominent tentacle or eye-speck at the junction of the tubes, but between the tubes there are, all round, two larger eye-specks, making altogether eight, arranged at equal distances in the intervals between the radiating tubes. This peculiarity is the more striking, as in most of the naked-eyed Medusæ the development of eye-specks seems to be prominently connected with the vertical chymiferous tubes and the marginal tentacles; while here the eye-specks are decidedly a morphological modification of the marginal appendages, being homologous to the tentacles with a simple eye-speck at their base, with which they are placed in one row and upon one level, differing in the degree and intensity of development, assuming a much more independent position, and leading almost to the peculiar arrangement characteristic of the common large Steganophthalmic Medusæ. The tentacles are not hollow, and no chyme is circulated in their interior in a more special manner than must take place everywhere in the process of assimilation. But here the chyme, as such, is not circulated in particular ramifications of the circular tube beyond the margin of the disk, while in Sarsia it penetrates into the four marginal tentacles. The tentacles all round the margin of the disk are of nearly uniform length, and of uniform size and thickness; though, upon close examination, sufficient differences may be perceived between them to satisfy us that their number is constantly increased by the additional development of new ones between the older (Fig. 13). This is especially striking upon comparison of very young specimens of Tiaropsis with more advanced ones, the number of tentacles being hardly one fourth of what it is at a later period, or, as the development is rather uniform in these animals, and almost all specimens caught at the same time are nearly equally developed, the comparison has to be made from recollection and memoranda of earlier states of growth contrasted with mature specimens, when it becomes plain that the eight large eye-specks, with few intervening tentacles, are developed very early (Fig. 14), and numbers of tentacles, with rudimentary eye-specks, are successively formed in the intervening spaces of the older ones (Fig. 15); but the larger prominent ocelli (Fig. 16), while they undergo their gradual development, remain unchanged in number, there being but eight of them throughout life. Their position, also, is rather singular: they are all at equal distances from each other (Plate VI. Fig. 5); but, with reference to the radiating tubes, they are placed so that one radiating tube meets the circular tube exactly midway between two eye-specks, thus dividing the continuous track of the circular tube extending between two such eye-specks into two equal parts, while between the next eye-

specks the circular tube runs undivided and unconnected with radiating tubes, there being only four of these latter; but next, again, a radiating tube reaches the middle of the space between the two following eye-specks; and so on, in such a manner that there are alternately two eye-specks on the two sides of a radiating tube, with two eye-specks between two radiating tubes, at a distance from each other of twice that from the tube to the eye-speck. This singular alternation is quite a prominent feature of the genus Tiaropsis, and seems to me the more interesting, as, up to the present time, it is the only known instance of the kind, and has not been noticed among the numerous otherwise similar forms which occur on the British shores, and have been so minutely described by Professor Forbes. Like the tentacles of Hippocrene, which are also destitute of an internal cavity, those of Tiaropsis elongate and shorten to a considerable extent (Plate VI. Fig. 13); but their power of extension and contraction can by no means be compared to what we see in Sarsiæ, which, at times, seem almost to drop their tentacles, so suddenly are they extended without any apparent action of the animal, and then draw them violently in again.

The eye-specks at the base of the tentacles are simply an accumulation of pigment-cells, closely packed together without apparent order or regularity. But not so with the large eye-specks. Each of them (Plate VI. Fig. 17) has within its base a large mass of very black pigment-cells, *a*, forming a sort of nucleus to a ganglion analogous to that of Hippocrene, in the formation of which the sensitive substance seems to take a considerable part. This ganglion is crowned by a diadem-like double wreath of peculiar cells, the inner row of which, *b*, may be compared to the basal eye-specks of the bulb of Hippocrene. There are about eight or nine such larger pigment-cells, forming a crescent at some distance from the opaque nucleus of the bulb; and above this rises another row of most elegant transparent pearl-like cells, *c*, encircling the former, which may be compared to rudiments of as many tentacles. If this view of the structure of these eye-specks is correct, each of them would correspond to one bunch of eye-specks, or one bulb, of Hippocrene; but of these bunches there would be eight in Tiaropsis, alternating with the radiating tubes instead of being connected with their base, and, in addition to these, a large number of simple tentacles with rudimentary eye-specks. I may be mistaken, but I cannot help being deeply impressed with the diversity of structure which exists among these lower animals, which is so great that the necessity of extensive comparisons between these structures, in order to ascertain their homologies and relations, seems to me almost of greater importance than among the higher animals; or, at least, as urgently called for to advance our science. Again, is not a comparison between the clusters of eye-specks in Hippocrene and the compound eyes of insects almost involuntarily called

forth here? And would it not be equally natural to extend similar comparisons to the larger eye-specks of Tiaropsis, and to view the small dark dots at the base of their tentacles as corresponding to the loose ocelli scattered more irregularly in spiders and other insects?

The position of the ovaries and spermaries (Plate VI. Fig. 3, 4, 5, 9, and 10) seems at first entirely different from that which exists in either Hippocrene or Sarsia. In those two genera the eggs and spermatic cells are developed, (as mentioned above,) upon the whole surface of the central digestive cavity. But in Tiaropsis they form four isolated bunches, placed upon the lower surface of the gelatinous disk, about midway between its central part and its margin, following, however, the radiating chymiferous tubes, to the external surface of which they are attached. This connection of the ovaries and spermaries with the radiating chymiferous system in Tiaropsis is certainly the same, morphologically, as in Sarsia and Hippocrene; though in the two latter genera the eggs and spermatic cells seem to be connected only with the outer walls of the central digestive cavity. However, if the arrangement of the ovaries in Hippocrene be examined very carefully, and their connection with the prominent angles and lateral surfaces of the central cavity be not lost sight of, it will indeed be seen that the development of the bunches of eggs corresponds strictly to the prominent angles of the central cavity, from which the radiating tubes arise, and which the eggs, in their development, follow to some extent before they are laid, as may be seen from Plate II. Fig. 23. Thus the whole difference between the sexual system of Tiaropsis and Hippocrene consists in the circumstance that the four angular bunches of ovaries, or spermaries, characteristic of Hippocrene, are somewhat displaced from the centre, and moved halfway towards the edge of the disk, to form the characteristic isolated ovaries and spermaries of Tiaropsis. Organically speaking, however, this difference is so trifling, that I should not be willing upon this basis to establish distinct families, as Professor Forbes has done; for morphology teaches us here, that there is no more difference in the position of the ovaries and spermaries in Tiaropsis and Hippocrene, than there is between the connection of petiolate and decurrent leaves with the stem to which they are attached.

At various periods during spring these organs appear very differently, being at first scarcely distinguishable as a slight ribbon-like swelling along the middle track of the radiating tubes. Later and later, as the ovarian and spermatic cells are more and more developed, they form a larger and larger fusiform body, swelling finally into prominent granulated bunches, varying in color in different specimens, from which at last the eggs are hatched. The state of development of the eggs, when they are cast, is rather advanced; for the germs are then ready to escape, or are indeed actually freed from the eggs, before

their envelope is cast from the ovary, the yolk undergoing the whole process of division before the eggs are laid, and the germ, when thus hatched, having a somewhat ovate form, but still a very uniform homogeneous structure. Such germs, recently hatched from eggs, I have seen move slowly, then attach themselves to the solid bodies in the jars in which they were kept, and grow into a Campanularioid polypidom, the history of which I shall give in another part of this paper. After the eggs have been laid, the ovaries are considerably reduced in size, and presently dissolve, when the animal soon dies. When forming, the eggs present all the characteristic structure of eggs in general, and hang in bottle-shaped sacs from the lower surface and the sides of the chymiferous tubes. I would only add, that I have repeatedly noticed a minute dot within the germinative spot; but of all the changes which the eggs undergo, I shall speak more fully when illustrating their metamorphoses.

Notwithstanding the very flattened form of the disk when compared with that of Sarsia, we may trace in these little spreading bells the same general arrangement of muscles as in Sarsia and Hippocrene. But it requires greater care to trace it fully, and it is more difficult to reproduce, in distinct appreciable drawings, the bundles which have been traced in highly contracted and distorted dead specimens. However, it is easy, in the first place, to see in living specimens, that the movements are entirely the same, and that the differences arise chiefly from the energy with which they are performed, in connection with the different permanent shape of the gelatinous disk. This disk being flatter, its margins thinner, and the lower partition, which extends inwards from the margin within the tentacles, narrower, the partition controls less powerfully the general motions than is the case in either Sarsia or Hippocrene, in neither of which do we ever see the lower partition unroll and turn inside out, as is so frequently noticed in Tiaropsis. This arises from the circumstance, that the partition is not only more lax and floating, but also narrower in comparison with the width of the gelatinous disk, and its spreading form. The muscular fibres in this partition are, as in the other genera, concentric and circular, combined with fewer radiating ones. The concentric fibres are by far the most prominent; their linear arrangement and cellular structure are easily seen, perhaps with even more ease than in any of the other types (Plate VI. Fig. 18).

The muscles of the disk are arranged precisely as in Sarsia or Hippocrene. There is an external superficial system of bundles hanging over the gelatinous mass, and simply covered by an epithelial film, which forms the outer coating of the body. This system is particularly loose and difficult to trace towards the periphery. This difficulty arises from the unfolding of the disk near its margin, where it is thinned out and readily bent outwards, and even upwards, as soon as the dying animal sinks and lies

flat upon the bottom of the glass plate, upon which it is brought under the microscope. It is therefore of the utmost importance to be first thoroughly acquainted with these changes of form of the whole animal, and especially with the unnatural fold which is formed at some distance from the margin in the contraction of death, before any further attempt is made to investigate the connections of the muscular apparatus of either the surface or the inner cavity of the disk. As soon, however, as we are familiarized with this difficulty, it is easily ascertained that there are in the disk three muscular systems, as in the preceding genera. For, besides the superficial system already mentioned, we trace, with the same ease, another on the inner surface of the gelatinous disk, which has the same general arrangement, its main bundles alternating with the radiating chymiferous tubes, and smaller bundles arising between these and the tubes; so that there are four chief bundles extending from the summit towards the lower margin of the inner surface of the gelatinous mass, and eight smaller ones alternating between these and the radiating tubes, besides some fibres which follow the tubes and have a more pennate arrangement. The only difficulty there is in tracing these muscles is in ascertaining that the superficial bundles and the inner bundles constitute two distinct systems; for here the gelatinous disk is so much thinner than in either Sarsia or Hippocrene, as to leave it frequently doubtful whether we have the fibres of the upper, or those of the lower surface in the focus of the microscope. Again, owing to the unrolling of the margin where the fold of the peripheric part of the disk is formed upon the more massy portion of the centre, there seems always to be a complete interruption in the course of the muscles; so that it requires more practice with these animals than with other genera before their contractile fibres can be traced for their whole length, the radiating chymiferous tubes themselves seeming frequently interrupted at the same place. I mention this difficulty for the sole purpose of removing at once the doubts which might arise in the minds of naturalists induced to repeat these observations, who otherwise might not at first perceive the cause of a discrepancy between the illustrations given here, and the appearance of specimens as they are seen at times under the microscope, though these circumstances have no reference to the real structure of the animal itself.

The third muscular system of the disk lines, with concentric circular fibres, the inner cavity, or rather the lower surface of the gelatinous disk. This system seems to be very powerful, even more so, comparatively, than in other genera; and, if we are allowed to trust the appearances, there seem to be, at a slight distance from the tentacular margin, about the lower extremity of the ovaries, stronger bundles of these fibres, which, when fully contracted, break the regular continuity of the outlines of the surface, forming a sort

of stricture between the upper disk and its margin. The circumstance that such contraction is observed in almost every dead specimen, while we hardly ever see the circular outlines of the lower margin deeply lobed or contracted into quadrangular outlines, plainly shows that in this type the circular muscles are more powerful than the radiating bundles of fibres. At the utmost, we notice slight undulations in the lower outline of the tentacular margin, between the radiating tubes, reminding us of the greater strength of the inner radiating muscles; the outer seem so delicate as to come into play only in connection with the inner, and perhaps to stretch the margins in the state of relaxation of the circular bundles and the lower radiating ones. At all events, the greater looseness of the outlines, the thinness of the disk, especially towards its margin, and the greater range of changes in the regular forms, agree with the particular modes of moving and feeding characteristic of this genus.

It were now very interesting to ascertain how far, among the numerous types allied to those which occur on the British shores, there is any resemblance in the arrangement or the greater development of their eye-specks, and the peculiar structure which characterizes the genus Tiaropsis. From Professor Forbes's descriptions, there seem to be no differences in the size of the eye-specks in any of his species of Thaumantias, to which genus I would have referred my Tiaropsis, were it not for the existence of two kinds of eye-specks around the margin, and the peculiar structure of the larger ones. I have given the name of Tiaropsis to this genus on account of the very peculiar structure of the eye-specks, of which no other example is yet known among Medusæ. For the species I would propose the name of *diademata*, as expressing more particularly the double wreath of the crown-like eye-bulb. The species is extremely common along the wharves of Boston harbour, and indeed throughout the bay, where it is constantly found near the surface, among Sarsiæ and young Ephyræ, early in spring and until about midsummer, when they disappear, soon after having laid their eggs.

In an ideal vertical section of Tiaropsis (Plate VIII. Fig. 11), corresponding in its position to that of Hippocrene, Fig. 3, and to that of Sarsia, Fig. 5, the relative position and natural connections of parts are illustrated in such a manner as readily to show the generic distinction between these types, and the homology of their different systems of organs. Without entering into any further details upon this subject, I will only mention that the letters in all the figures correspond precisely to each other, and may therefore, with ease, be referred from one genus to the other.

THAUMANTIAS.

On comparing the Fauna of the British coast with that of the United States, for their Medusæ, there appears a very striking difference between them; for, though some of the types occur on the two shores, there are others which seem peculiar to each. No doubt this difference, great as it appears at present, will be gradually lessened as more and more extensive investigations are made among the Medusæ of the American shores. Had not Professor Forbes devoted so many years to the study of this class, we should certainly be unacquainted with so great a diversity of British Medusæ as he has so well described. However, the occurrence of so large a species as Staurophora among the few Medusæ noticed on the shores of Massachusetts, when nothing of the kind has been noticed on the shores of Great Britain, after the thorough search made by Professor Forbes and Captain McAndrew, indicates plainly that the two countries do not agree fully in their Acalephæan Fauna. We have here Aurelia, Cyanea, Rhizostoma, and Pelagia among the large Medusæ, as they occur also on the shores of Great Britain; but no Chrysaora, nor any Cassiopea, has yet been found here, nor have representatives of the genera Willsia, Circe, Oceania, Saphenia, Turris, Stomobrachium, Tima, Geryona, Slabberia, Moderia, Geryonopsis, Lizzia, Steenstruppia, and Euphysa been found. But here we have Staurophora, which does not occur there; and the genus Thaumantias, of which so many species have been discovered on the British shores, has yielded only two representatives on the American shores, up to the present day; while a species closely allied to Thaumantias is found in great abundance on the shores of Massachusetts, but differing from the true Thaumantias in peculiarities striking enough to constitute a genus by itself, of which no analogous representative has yet been found elsewhere. For that genus I have proposed the name of Tiaropsis, alluding to the peculiar form of its eyes, which are not connected with the tentacles, but alternate with them, and are surrounded with a crown of globular vesicles, forming a diadem above the black speck. Another genus peculiar to the United States is my Nemopsis. The first species of Thaumantias proper which I observed in this country was caught off Gay Head, and in Edgartown harbour, under circumstances which did not allow me to have it drawn with sufficient details, and to investigate its structure with any degree of accuracy. All I could do was to ascertain that it truly belonged to the genus Thaumantias, having round the margin short tentacles with an eye-speck at their base, the tentacles being alternately longer and shorter, one of the longer arising from the base of the four radiating chymiferous

tubes, and two of the same length intervening between two tubes, and alternating with shorter ones; the mouth forming, as in the other species, a small bell-shaped peduncle, with four lobes spreading sideways and fringed along their margins; the ovaries attached in the shape of ovate bodies on the lower side of the chymiferous tubes, about the middle of their length. This species is very minute, scarcely a line in diameter, and perfectly transparent and white, excepting the dark eye-specks at the base of the tentacles, the ovaries having a light tint of yellow.

1.

I propose to call this species *Thaumantias diaphana*. I subjoin a wood-cut of the rough sketch made at the time. It was dredged with a gauze net from the surface, on the 25th and 26th of June, 1849. Fig. 1 represents this little Medusa as seen from above; Fig. 2 shows it in profile.

2.

While this sheet was passing through the press, Mr. Charles Girard, my assistant, brought me another species of Thaumantias, taken by him on the beach at East Boston. Though it was in a rather indifferent state of preservation, I could satisfy myself that it differs specifically from the former, inasmuch as it has narrow, elongated ovaries; thus showing that the two types of Thaumantias which have been noticed in Great Britain occur also along the shores of the United States. The size and time of appearance speak also in favor of the specific difference of these two Medusæ, as the first, observed towards the end of June, was very small, and the other, caught early in May, was a full grown-animal, over one inch and a half in diameter, and similar in form to *Thaumantias Pilosella*.

STAUROPHORA.

The genus Staurophora was established in 1835, by Professor Brandt, in his Prodromus of a Description of the Animals collected during a Voyage round the World by H. Mertens, published in the Transactions of the Imperial Academy of Sciences of St. Petersburg, in 1835.

The genus was established by Brandt from the drawings and memoranda of Mertens. Afterwards, a fuller account of it was given by Brandt, in his extended Description of the Medusæ collected by Mertens, published also in the Transactions of the Imperial Academy of St. Petersburg, in 1838, Sixth Series, Part Second, Vol. II. p. 399.

The genus is characterized as follows: — No mouth, according to Mertens; — on

the lower surface numerous arms, (fringed folds of the margin of the mouth,) which form two stripes or ribbons alternating with each other in such a way as to constitute a cross; — the margin of the disk furnished with numerous tentacles.

This new genus is there represented as differing from Eudora by the presence of suckers and marginal tentacles; and from Berenice, which possesses long marginal tentacles, in the foliaceous arms arranged in the shape of a cross. In the possession of arms it shows a resemblance to *Medusa campanulata* [*Melicertum*]. But this latter genus has thread-like arms, and the tentacles around the margin are in several rows, of unequal length. The specific description there given, and the figures reproduced from Mertens's drawings, under the name of *Staurophora Mertensii*, afford some further information upon this remarkable animal.

It is described as being slightly convex, clear as water, and perfectly transparent. Each arm of the cross, which is tinged more or less deeply with blue, possesses on each side from seventeen to twenty-one arms, each of which has a lanceolate or a linear-lanceolate and undulating or fringed margin and acute terminations. The arms hang downwards with their free margin, but remain united at the base by a narrow continuous membrane extending for their whole length, from which issue a few additional small processes or appendages.

Brandt says that it may be possible, as Mertens maintains, for these arms to absorb nourishing substances, in a manner analogous to that of the Rhizostomata, in which the arms, however, have a different structure. The fact that the four peripheric extremities of the arms of this cross terminate in a distinct marginal vessel would sustain this view. Numerous tentacles, by no means remarkable for their length, are in connection with this marginal vessel. Within the margin to which the tentacles are attached, there is a prominent seam.

The movements of this animal are very characteristic. It can, not only change its form and place after the fashion of other Medusæ, but also contract in such a manner as to assume the form of a regular four-rayed star, thus somewhat resembling an Asterias; this form it assumes very frequently.

The first specimens of this Medusa were collected in Norfolk Sound; it was observed afterwards in the ocean of Oonalaska, and finally, on the 20th of August, 1827, it was seen from the Senjevin on her trip between Sitka and the Aleutian Islands.

This is all we know at present about this remarkable form of Medusa, as nobody has ever seen any animal of that genus before or since. Its natural position among Discophorous Medusæ is rather doubtful. Brandt places it, with doubt, in that family which

Eschscholtz established in 1829, under the name of Berenicidæ, for two genera circumscribed before by Peron, of which he himself never saw any representative.

Eschscholtz himself is not very precise in his characteristics of the family Berenicidæ, as he only mentions that these animals are reported to have no digestive cavity, but simply ramified vascular tubes, which probably absorb their food by a number of apertures, or perhaps short suckers, in which respect he says they would resemble Rhizostomata. The only genera known, Eudora and Berenice, were established by Peron. Their disk is rather flat, but the genus Eudora is characterized by a want of marginal tentacles; Berenice, by the presence of rather long appendages of this kind.

Brandt adds to the rather meagre characteristics of the family Berenicidæ, as established by Eschscholtz, that this family is probably not to stand, though he does not give any reason for his opinion, nor does he mention where his new genus Staurophora should be referred, in case Eschscholtz's family were broken up. However, that Staurophora is really closely allied to the two genera of Peron, which constitute Eschscholtz's family of Berenicidæ, cannot be doubted for a moment, from a comparison of the figures of Peron with those of Mertens published by Brandt. Such is the amount of our knowledge, or rather the deficiency of our knowledge, respecting some of the most important details of the structure of Medusæ, that we are at a loss to assign to this group of jelly-fishes their proper natural position, until further investigations are made upon the subject.

There is something so repugnant to the physiologist in the thought of animals of the size of Staurophora, that is to say, measuring several inches in diameter, being deprived of mouth and stomach, that, of all the naturalists who have read attentively such descriptions, there is probably not one who has been willing to regard this as really a correct account of these animals, who would not have considered himself peculiarly fortunate in having an opportunity of reinvestigating carefully such types, and who would not, under such circumstances, make a reëxamination of the alimentary canal, and a search for the stomach and mouth, the first object of his investigation; so little are we prepared, and so little reason is there, on the whole, to give credence to assertions which come in direct conflict with the most carefully established results in physiology.

I have scarcely ever valued any discovery more highly than that made by my secretary, Mr. H. Huber, of one specimen of well-characterized Staurophora, in Boston harbour, in the early part of the summer of 1849. My first care was to look for the central cavity, and an external opening communicating with it; and I must say, I had scarcely looked, when I found both; but I must also confess, that I do not wonder that neither was discovered before.

Let me first state, that the species found in Boston harbour belongs really to Brandt's genus Staurophora; for if there should be any doubt upon this point, all further generalization might be perfectly unfounded.

Staurophora is a genus of Discophorous Medusæ. My new species resembles so much, in its general appearance, the common Medusa (*Aurelia aurita*), that the first specimen, which was brought to me by Mr. Huber, came in a jar of specimens of that species, for which I had sent, and was brought up without being noticed. I, however, afterward secured a great number of them, which were collected both by Mr. Charles Girard and Mr. Huber, so that I have had ample opportunity to study fully the form and structure of this animal, which is really an intermediate type between Eudora and Berenice, having rather short marginal tentacles, similar, indeed very similar, to those of Thaumantias; and our species might easily be mistaken for something like *Thaumantias Pilosella*, were it not for the want of central oral lobes or stomachal appendages, instead of which we notice a simple cross extending nearly to the very margin of the animal, and consisting of a membranous seam hanging downwards, in a manner almost identical with that of *Staurophora Mertensii*, but differing, however, in its lobulation, the margin of these membranous seams being only deeply undulated, but not pectinate.

The motions of the species of Boston Bay agree also remarkably with the description given by Mertens of the species observed on the northwest coast of the American continent. When progressing slowly, they advance like all Discophorous Medusæ, by alternately expanding and contracting the margin of their disks, and assuming successively the appearance of a disk or that of a half-sphere. In this respect they closely resemble the common Medusæ. But when they contract more powerfully, they assume a very different aspect. The angles of the cross become prominent, and the intervening spaces are contracted in such a way as to give the whole disk a quadrangular form, or even that of an emarginate four-rayed star, precisely as Mertens has observed it in his species described by Brandt. The resemblance in form, in movement, in the position of the marginal tentacles, in the disposition of the arms, as Brandt called the fringes forming the cross on the inner lower surface of the disk, can, I trust, leave no doubt in the mind of any naturalist, that the Medusa I am about to describe really belongs to the genus Staurophora of Brandt.

It cannot be doubted, therefore, that whatever additional details of structure may be observed in one will also sooner or later be discovered in the other; and whatever conclusion may be established respecting their systematic position will equally apply to Eudora, Berenice, and Staurophora.

Now, in the first place, I would mention that the disk presents a mass of gelatinous

substance, contained in rather large cells, like those of the vitreous humors of the eye, covered externally by a flat pavement epithelium of irregular nucleated cells, forming a film which is deciduous soon after the animal has perished; but even during life, after injuries upon the surface, this coating is seen to peel off, and the animal gradually decays by superficial decomposition.

The disk is flat-hemispherical, its margin more or less expanded as the animal is in a more relaxed or contracted state. Muscular fibres run in two different directions through its whole mass; part of the fibres being radiate, and others concentric. The radiating fibres are in larger bundles, and appear particularly active upon three points in each of the four intervals embraced by the four arms of the cross; there is, however, also a bundle in the prolongation of the ray of the cross itself, and similar smaller bundles alternate again with those already mentioned. So that, upon contraction, its radiating muscles may cause the disk, or at least its margin, to fold into more or less numerous lobes, according to the intensity of contraction of the more powerful of these bundles.

The concentric muscles are disposed in such a manner as to form concentric squares rather than concentric circles, the sides of which extend from one arm of the cross to the other; and upon strong contraction, assisted by the main radiating bundles which alternate with the rays of the cross, they give the animal in its most powerful contractions the appearance of a square body rounded upwards.

The diversity of forms and appearance which this animal may assume in its contractions is so great, that I have been induced to multiply the figures representing it, in order to give a full idea of their distinctive peculiarities. It was the more important to do so, as in a dying condition they would at times assume permanently one or the other of these forms, which, if observed singly, might easily be mistaken for a special modification of structure, and give rise to an erroneous distinction of species. But as I have observed these animals for days and weeks, I know that these are only temporary modifications of the same species, as I have seen the same individual present, at different periods, all the forms here illustrated. (Plate VII. Fig. 1 – 8.)

We must consider as the margin of the disk the edge from which the tentacles spring and hang down, though this edge is more or less curved in when the animal is in gentle activity, as this is the most prominent margin when the animal is in the greatest state of relaxation, and spreads almost flat like a disk (Fig. 9). The tentacles are very numerous, seemingly of equal length and size; yet upon close examination it may be seen that there are thicker and thinner, longer and shorter ones, alternating with each other; but the difference is so slight as, at first view, not to strike the observer. Their length is less

than half the diameter of the disk, even in their most relaxed state. Usually they form only a graceful fringe all round the disk, about one sixth of the whole diameter in breadth.

These tentacles are hollow, and their cavity, which is wider near their base than towards the tip, opens into a circular canal, which extends all round the disk along the bases of the tentacles. Underneath and within the tentacles, there is a further prolongation of the disk, in the shape of a seam stretching inwards, and forming, as it were, a partition of the cavity below the disk. But as this seam is rather narrow, the cavity itself is widely open, and the seam, in general, can hardly be considered as any thing more than a mere membranous inner prolongation of the disk, or of the margin of the disk, from which the tentacles issue. The existence of such a seam should not be overlooked, as it is a point in the structure of the Medusa under consideration which is probably common to all the genera, and only more or less developed in the different types. For instance, the inferior opening of Hippocrene is very small in comparison with the whole width of the animal, which, consequently, has the lower surface of its disk almost shut out from immediate contact with the surrounding water. Such is the case, also, in the genus Sarsia, whilst in Thaumantias, as in Staurophora, the flatness of the disk and the narrowness of its inner seam make this feature less prominent. As in all the Medusæ in which it has been observed, this seam is contractile ; concentric fibres prevailing in it, though there are also a few radiating ones, by the powerful contraction of which this seam is at times reversed outwards, so as to cover the base of the tentacles. Specimens which have died in such a position might also easily be mistaken for peculiar species.

At the base of each tentacle there is, on its inner surface, a black eye-speck, varying in size in proportion to the size of the tentacle itself. The form of these eye-specks is less regular than in most other naked-eyed Medusæ ; the pigment-matter forming rather irregular heaps, dark in the centre, with the margin vanishing away into the surrounding substance. But, however indefinite these specks may be, (and they appear as perfectly distinct dots to the naked eye, and only under higher magnifying powers seem less defined at their margin,) they must, physiologically speaking, be considered to be the same organs as similar specks upon the margin of the disk of most other Medusæ. The tentacles themselves, in their contraction, are not only shortened and lengthened ; but they coil spirally, and the coil is twisted from right to left downwards, or from left to right upwards, all around the disk, without antitropic direction of those of different parts of the periphery.

The diversity of the forms which Staurophora assumes is truly wonderful. It may

appear as a flat disk entirely spread out, the marginal tentacles spreading also in the same plane. Or the disk may be swollen slightly into a flat hemisphere, with a uniform curve from the margin to its summit, the tentacles hanging down at right angles all around (Plate VII. Fig. 10, 11). Or the prominent disk may be more swollen in the centre than towards the margin, which may spread, while the central part of the disk is considerably raised. Again, the whole disk may be contracted so much as to form a regular rounded hemisphere (Plate VII. Fig. 1), with hanging marginal threads; or the margin may be still more contracted, and give the whole body an almost spherical shape, when the lower opening is perhaps reduced to half the diameter of the globular body.

Again, the muscles may contract in such a manner, as to give a quadrangular form to the disk with rounded angles, and the upper portion may be more or less raised (Plate VII. Fig. 8). In such a position, the margins are inflected inwards between the arms of the cross, and the fringes form also a more or less quadrangular fringe, and the inner seam is bent over between the arms of the cross, and covers them more or less. If, in such a position, the animal contracts still further, and the radiating muscular bundles between the arms be particularly active, the quadrangular shape of the outline may be still more brought out, and it may even assume the form of an emarginate four-rayed star, when the inner seam covers almost entirely the arms of the cross, and shuts completely the lower surface. In that case the marginal fringes are bent inwards, and the lobes in which they are inserted form, as it were, four valves, moving up and down, and alternately opening and shutting the lower cavity. Finally, the contraction of the radiating muscles may be such as to divide the fringed margin into more or less numerous lobes (Plate VII. Fig. 7), which may form an undulating circle, or more or less prominent lobes almost as completely isolated as if they were separated by fissures.

In order fully to understand the structure of the central cross of the lower surface, it is necessary to be acquainted with the morphology of the mouth of other Medusæ, and to have traced its successive changes in some of the higher Medusæ, from its earliest condition up to the time when it assumes there its most complicated structure.

In the young Aurelia, the mouth is a mere quadrangular opening, with prominent margins. These margins, however, soon project; the angles become more prominent, and then elongate; and this elongated portion at length widens and is enlarged into flat tentacles, frequently called by zoölogists the arms of the mouth. In the perfect adult Aurelia, the mouth is a simple cross-fissure, with prolonged thin, membranous margins. The margins of each arm of such a cross are laid flat against each other, and constitute compressed channels opening into the mouth.

Now let us for a moment suppose that such a mouth, instead of being confined to a

limited space of the central portion of the disk, were to extend, as a long, radiating arm, from the centre to the periphery, and that its margins were not elongated, but consisted merely of narrow ribbon-like membranes laid flat against each other, and following the fissure of the mouth with uniform width for its whole extent, and that its membranes were more or less lobed along their whole margin, and we should have the mouth of Staurophora.

Indeed, in our Medusa this cross consists of a narrow fissure in the centre (Plate VII. Fig. 15 and 12), towards which the four arms converge; and each arm of the cross, when properly examined, is found to consist of a narrow fissure, inclosed by two membranes pressed against each other; but the lower margin of each diverges somewhat, and is undulated and lobed for its whole length. Near the periphery, however, the two membranes of each arm converge and unite (Fig. 13 and 14), and thus close the fissure completely, and turn it into a narrow tube, which extends further and communicates freely with the circular tube extending along the base of the tentacles. Upon unfolding these double membranes along each ray, it is easy to penetrate into the fissure between them, and also to ascertain that this fissure is continuous, and that the fissures of the four arms of the cross meet in the centre in an oblong open space surrounded by folds inclosing the four fissures, which meet here in continuous lobes, and thus form a free entrance to the central cavity, which extends into the arms.

There can be, therefore, no mistake about the real nature of this open space, and the fissures with which it communicates. The central opening (Fig. 12, *a*) is the mouth; the four fissures of the four arms of the cross are its extensively prolonged angles; and the fringes which encircle them are the ribbon-like fringed margin of the mouth, and are truly homologous with the mouth of all other Discophorous Medusæ. So that Staurophora, far from being destitute of mouth and stomach, is formed upon the same plan with the common Discophorous Medusæ, with this single difference, that the opening of the mouth is very narrow and small, and somewhat oblong, and its angles very prominent externally, and unusually developed.

But we have direct evidence that this cross-like opening is really the mouth, and that its whole extent is to be considered as the opening of the mouth, and the central cavity more properly as the main cavity of the body: for I have often seen this Medusa feeding upon other species of small size. In a glass jar, in which I kept alive for weeks specimens of Staurophora with various kinds of Sarsiæ, Tiaropsides, and young Aureliæ, I have often seen the Staurophora seize upon the smallest of these animals, inclose them between the folds of its central cross, and swallow them gradually, completely surrounding them by its folds. Such small Medusæ were seized, not only

by the central portion of the star-shaped fissure, but also upon any point in the extent of the star, and at times I have even seen two Sarsiæ entangled between the folds of the mouth, one at the very peripheric extremity of an arm of the cross, and the other near the middle of another arm, as represented in Plate VII. Fig. 11. So that there cannot be left a shadow of doubt as to the real nature both of this fringed star and its fissure, as well as the central open space.

Staurophora has, we can say positively, a narrow, oblong mouth, with extensively prolonged angles reaching nearly to the margin of the periphery, where the folds converge and unite, and give rise to a narrow vascular radiating tube, identical with the chymiferous tubes in Sarsia and Thaumantias, and other naked-eyed Medusæ. In Staurophora the only difference is the relative shortness of these radiating tubes, which are shorter than in other genera in proportion to the greater extent of the cavity of the mouth; but here, as in all, the mouth, central cavity, and radiating tubes communicate with the marginal circular tube, and through it distribute the digested food into all parts.

Respecting the form of the central cross, I have further to remark, that in our species the fissure formed by the folds of the membrane of the mouth is undulated in its course, as well as the membrane itself, and that the lower margin of the membrane is deeply but irregularly lobed. In that respect the species from Boston Bay differs from that of the Northwest Coast, in which, to judge from the figure of Mertens, the canal is straight, and, as expressly mentioned by Brandt, the surrounding membrane, which hangs down, is deeply cleft into fringed distinct lobes; so that there can be no doubt as to the specific distinction between the two species, though they otherwise agree closely. From the peculiarities just described, I propose to call the Eastern species *Staurophora laciniata*, Brandt having named the other species after its discoverer, the able and lamented Mertens.

I have little to say respecting the organs of reproduction, as my specimens were collected at a season when the eggs did not seem to have advanced far in their development. I can only state that they are grouped as in Thaumantias, along the radiating chymiferous tubes, where they form a narrow elongated cluster, extending from the extremity of the cross along its fissure for some way towards the centre, where they are lost at about one third of its length. How large the eggs grow before they are mature has not been ascertained, nor could their microscopic structure be satisfactorily investigated, as they seem more closely imbedded in the substance of the disk than in other species, and are always crushed when separating the fringes from the disk.

Staurophora laciniata has a light, bluish milky color, and is very transparent, though less so than most of the species of naked-eyed Medusæ. I have, for that reason, been

unable to make out distinctly the nervous ring, which, in other species, follows the circular marginal tube, though I observed a thread accompanying it, which may correspond to the distinct nervous cord noticed in Sarsia, Tiaropsis, and Hippocrene. The marginal fringes are of a light rosy color, and the folds of the mouth either rosy or yellowish.

From the preceding description, it must be plain that Staurophora belongs to the same family with Thaumantias and Tiaropsis. These genera agree in every respect in their structure, and the differences which occur between them can only be considered as generic. In all, we observe the same narrow central cavity, with a narrow fringed mouth; in all, chymiferous tubes arise from the central cavity, and communicate with a peripheric circular tube; in all, we have slender tentacles connected with the margin of the disk, and naked eye-specks at their base. And though such eye-specks are neither mentioned in Brandt's description of Staurophora, nor in the Eudora and Berenice of Peron, and though, in the two latter genera, no chymiferous tubes are described, which, at that time, were not known in any of the Medusæ, I have no doubt that both Eudora and Berenice belong also to the same family, Eudora forming the lowest stage in the development of a structure which is more developed in the others.

The figure of Peron exhibits the small central depression, with four radiating furrows, no doubt the analogues of the mouth of Staurophora, but differing in the deficiency of marginal folds and a prolonged membranous edge, while in Berenice a similar central cross is observed branching towards the margin, as in Forbes's genus Willsia, and, as the figure seems to indicate, provided in its peripheric ramifications with lobules, like those of the Western Staurophora; so that their natural relation cannot be mistaken. If all this be correct, we should at once strike out of our systems Eschscholtz's family Berenicidæ, as an artificial group, resting upon imperfect knowledge of the structure of the animals for which it was instituted; for it can now very properly be combined with that most natural group, first fully understood and characterized by Professor Edward Forbes, the naked-eyed Discophorous Medusæ. A comparison of an ideal vertical section of Staurophora (Plate VIII. Fig. 12) with those of the genera Hippocrene, Sarsia, and Tiaropsis (Fig. 3, 6, and 11) will satisfy the most skeptical of the close relation of these genera, and justify my assertion, that Staurophora is truly a member of the family of naked-eyed Medusæ. The letters indicating the different organs in this section correspond precisely to those indicating the homologous parts in the other genera; and need, therefore, no further explanation.

*** The impossibility of adopting a systematic course in describing the Medusæ considered in the preceding pages will render their perusal somewhat difficult; and I deem it, therefore, necessary to indicate briefly the substance of the different paragraphs, in order to faciliate the reading of this paper, and to render references to it less troublesome.

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EXPLANATION OF THE PLATES.

Plate I. — Hippocrene superciliaris.

Figures of natural size and enlarged in different positions. Fig. 1, 2, 3, and 4, enlarged; Fig. 5 to 11, of natural size, slightly exaggerated. Compare page 257.

Fig. 1. Enlarged, seen in profile, slightly overhanging, with the tentacles raised, while in Fig. 5 they are spreading sideways and downwards.

Fig. 2. Seen from below, the mouth in the centre, and the branching fringes around it; the four sensitive bulbs, with the eye-specks, beyond which the tentacles are extended; the circular chymiferous tube and the nervous cord on its inner margin; the undulations produced by the inner muscles, and the inferior partition.

Fig. 3. Seen from above, the central digestive cavity being empty, and the four radiating chymiferous tubes very prominent. The chief difference between this figure and the preceding consists in the contracted state of the tentacles.

Fig. 4. In the same position as Fig. 3, only the tentacles are still more contracted, the central digestive cavity distended, and bunches of eggs are hanging around it.

Fig. 5. A specimen suspended motionless in the water, with its tentacles extended.

Fig. 6. The same, seen from above.

Fig. 7. Specimen contracted to the utmost, turned upside down, with its tentacles drawn in and the lower partition turned inwards.

Fig. 8. The same, seen in profile, somewhat turned sideways.

Fig. 9. A specimen contracting to push forwards, the tentacles following behind.

Fig. 10. A specimen in a similar state of contraction, moving sideways.

Fig. 11. A specimen at rest, as those in Fig. 1 and 5, but the tentacles drawn in.

Plate II.

This plate represents microscopic details of *Hippocrene superciliaris*.

Fig. 1. A tentacle raised upwards, with a dark eye-speck, *a*, at its base; *b*, an elongated portion of the tentacle; *c*, its middle in a more contracted state, and *d*, the tip. See page 270.

Fig. 2. The tip of the tentacle much enlarged; *a*, the larger inner cells; *b*, the smaller outer cells.

Fig. 3. A portion of the tentacle in an elongated state, much enlarged; *a*, the large inner cells; *b* and *c*, the smaller external ones.

Fig. 4. The tip of the tentacle, in a less elongated state than in Fig. 2; *a*, the large inner cells; *b*, the smaller external ones.

Fig. 5 and 6. Superficial epithelium. In Fig. 5, which is taken from the upper surface of the disk, the cells are very distinct and polygonal, some of them containing nuclei. In Fig. 6, which is taken from the lower margin, the cells are irregular, and their nuclei still more so.

Fig. 7. A part of the central digestive cavity, with the crosier-shaped radiating tube rising from one of its corners; *a*, the central cavity itself; *b*, the origin of the radiating tube; *c*, the arch which it forms above the digestive cavity. See page 264.

Fig. 8. The lower extremity of the radiating tube branching into the circular tube; *a*, the dilatation of the tube behind the sensitive bulb, from which the two branches of the circular tube, *b*, *b*, arise; *c*, the vertical part of the descending tube.

Fig. 9. A portion of the vertical tube; *a* indicating its cavity, and *b* its walls, which are equally distinct in Fig. 7 and 8.

Fig. 10. The upper arch of a radiating tube, in a position somewhat different from that in Fig. 7; in Fig. 7, the tube is in perfect profile, so that its inner cavity, *c*, contrasts closely with its walls, *b*; while, in Fig. 10, the tube is seen from above, *a* indicating its cavity, *b* and *c* its margins.

Fig. 11. A sensitive bulb in its normal connection with the vertical radiating tube, *e*, and the circular tube, *b*, *b*, much enlarged; *a* representing the nervous cord; *c*, the sensitive bulb; and *d*, the part of the tentacles with the eye-specks at their base. See page 268.

Fig. 12. The sensitive bulb seen from below, slightly enlarged.

Fig. 13. The sensitive bulb in a position similar to that of Fig. 11, but the tentacles hanging downwards; in such a position the connection of the radiating tube, *b*, with the circular tube, *a*, *a*, is very obvious. The eye-specks are indistinctly seen through the tentacles, *c*, *c*.

Fig. 14. The sensitive bulb in its connection with the lower partition, seen from below, the tentacles stretching horizontally; *a*, *a* represent the eye-specks; *b*, *b*, the tentacles slightly elongated, while their base, *c*, *c*, is considerably stretched; *d*, *d*, the ganglion of the bulb into which the nervous cord, *f*, *f*, penetrates; the dark cones arising from this ganglion point to the centres of the eye-specks; *e*, *e* being the circular chymiferous tube rising behind the bulb to unite with the vertical radiating tube; *g*, *g*, the muscular lower horizontal partition.

Fig. 15. The sensitive bulb raised and seen somewhat from the side, most of the tentacles raised upwards, while the lateral ones hang downwards. In this position, which the sensitive bulb assumes chiefly when the body is contracted, the bulb itself is folded into three lobes, one corresponding to the largest middle tentacle, the lateral lobes being formed by the tentacles of the two sides.

Fig. 16. A view similar to that of Fig. 14; *a* being the eye-specks; *b*, the circular tube; *c*, the nervous cord; *d*, the elongated tentacles; and *e*, the pigment cones of the ganglion.

Fig. 17 represents the lower margin of the body with two sensitive bulbs, one on the right, seen from without; one on the left, seen from within; *a* being the circular tube; *b*, the nervous cord; *c*, the lower muscular partition; *d*, *d*, the vertical radiating tubes; *f*, the inner vertical muscles; and *e*, the outer wall of the body.

Fig. 18. The central digestive cavity (see p. 260); *a* being the mouth shut; *b*, *b*, the transparent tissue forming the outer wall of this cavity; *c*, *c*, the main stems of the tentacles of the mouth; *d*, *d*, their terminal branches; *e*, *e*, the radiating tubes arising from the upper corners of the digestive cavity; *f*, the upper wall of the cavity; *g*, *g*, eggs imbedded in the surface of the digestive sac.

Fig. 19. The digestive cavity seen from above, with its four radiating tubes, *a*, *a*; *b* being a temporary swelling at the base of one of the radiating tubes; *c*, the centre of the cavity; *d*, *d*, its walls.

Fig. 20. A more enlarged view of the same, also seen from above; *a*, *a* being the radiating tubes, somewhat dilated at their base, *b*, *b*, containing granules which circulate to and fro from the central cavity into the radiating tubes; *c*, *c*, bunches of eggs upon the outer surface of the digestive sac.

Fig. 21. Mouth entirely open, seen from below, allowing a sight into the cavity of the digestive sac; *a*, *a* being the margin of the mouth; *b*, the main stem of the tentacles of one of its angles; *c*, *c*, the tips of the tentacles; *d*, the folds of the inner surface extending into the base of the radiating tubes; *e*, *e*, brown cells lining the inner surface of the cavity.

Fig. 22. The central digestive cavity in its most contracted state; *a*, *a* being its prominent angles, corresponding below to the four bunches of tentacles, and above to the base of the four radiating tubes; *b*, the central cavity reduced to the utmost by contraction; *c*, the folds between the prominent angles of the sac.

Fig. 23. The mouth, with its tentacles and bunches of eggs surrounding the central cavity, seen from below. The mouth, *a*, with its four folds, *c*, and its transparent margin, *b*, is figured as complete; but only two bunches of tentacles, *d*, *d*, and two bunches of eggs, *f*, *f*, are fully represented; *e*, *e* indicate the tips of the tentacles.

Fig. 24. A terminal branch of the tentacles, to show their irregular terminal divisions.

Fig. 25 represents such a branch more highly magnified, to show the large internal cells, *a*, *a*, and the coating of smaller cells, *b*, *b*, surrounding them; *c*, *c* being the terminal nettling cells.

Fig. 26 represents another terminal branch of tentacles less magnified, but showing, also, distinctly the large internal

cells, *a*, and the transparent margin consisting of small cells, *b*, *b*, and the projecting nettling cells at the tip of the branches, *c*, *c*.

Fig. 27 represents a heap of such nettling cells.

Plate III.

This plate represents chiefly the muscles and nerves of *Hippocrene superciliaris*, all the muscles being printed blue.

Fig. 1 and 2 represent the superficial muscular bundles. See p. 275.

Fig. 1. *a*, *a*, *b*, *b*, *c*, *c*, bundles of vertical fibres; *d*, *d*, connecting fibres between the upper and lower row of circular fibres; *e*, *f*, main vertical external bundles; *g*, *h*, secondary vertical bundles.

Fig. 2. *a*, *a*, circular fibres; *b*, *b*, *c*, *c*, inner circular fibres; *d*, *d*, main vertical bundles; *e*, *e*, secondary vertical bundles; *f*, *f*, muscular fibres of the lower partition.

Fig. 3 and 4 represent the inner muscles in two different views.

Fig. 3. *d*, *d*, main vertical bundles; *e*, *e*, *f*, *f*, secondary vertical bundles; *g*, *g*, bundles of the radiating tubes; *i*, circular bundles.

Fig. 4. *b*, *b*, *c*, *c*, double outlines of the circular fibres; *d*, *d*, main vertical bundles; *e*, *e*, *f*, *f*, secondary vertical bundles; *g*, *g*, bundles of the radiating tubes; *h*, oblique fibres of the inner wall; *i*, inner circular fibres; *k*, circular fibres of the lower partition.

Fig. 5. Nervous system (see pp. 266 and 271); circular nervous cord below; vertical threads following the radiating tubes; upper cord between the curves of the radiating tubes, with plexuses under their arches, and descending threads midway between two radiating tubes; all drawn in continuous dark lines.

Fig. 6. The plexuses under the arches of the radiating tubes.

Fig. 7. Seen from above, to contrast the outer and the inner systems of muscles; *a*, *a*, the main vertical external bundles; *b*, *c*, the double outline of the inner circular system; *d*, the main inner vertical bundles; *e*, *f*, the secondary inner vertical bundles; *g*, the outer secondary vertical bundles; *i*, the inner circular fibres.

Fig. 8. Also seen from above; but the inner vertical bundles less projecting; *a*, *a*, the outer main vertical bundles; *b*, *b*, the outer secondary vertical bundles; *d*, *d*, the main inner vertical bundles; *i*, the circular inner bundles; *k*, the circular bundles of the lower partition.

Fig. 9. Seen from above, the outer muscles being neglected; *b*, *c*, the double outline of the inner circular bundles; *d*, the main vertical inner bundles; *e*, *f*, the secondary inner vertical bundles; *i*, the inner circular bundles; *k*, the lower partition; *m*, the nervous cord; *o*, the circular chymiferous tube.

Fig. 10 and 11. Contractile cells in different states of elongation, with their nuclei.

Fig. 12. Circular fibres of the lower partition.

Fig. 13. The cells of the main nervous cord.

Fig. 14. The lower partition, with a sensitive bulb; *a*, sensitive bulb; *b*, circular chymiferous tube; *c*, nervous cord; *d*, radiating fibres of the lower partition.

Fig. 15. Lower margin of the body; *a*, lower partition; *b*, nervous cord; *c*, circular chymiferous tube; *d*, vertical bundles of the outer wall.

Plate IV. — Sarsia mirabilis.

The figures of this plate represent this species in various natural attitudes, as it is observed swimming through the water, all the figures of natural size, excepting Fig. 1, 2, 3, and 4, which are enlarged to show more distinctly the different parts.

Fig. 1, 6, and 7. In attitudes of rest, when the gelatinous disk stands upright, and the four tentacles, stretched at right angles sideways from the lower margin, are bent suddenly, and hang loosely downwards.

Fig. 1. The large proboscis hangs down beyond the lower margin of the disk. The connection of the four radiating tubes with the circular tube of the lower margin and the hollow tentacles is plainly shown. In Fig. 7, two of the ten-

tacles are left out, to show more plainly this connection and the connection of the radiating tubes with the central cavity and the proboscis.

Fig. 2. As seen from above, the proboscis being retracted and coiled up within the main cavity of the disk. Here, also, the connection of all parts is plainly shown, and the outlines of the interior muscular system well defined.

Fig. 3. Seen from below, the tentacles being cut near their base.

Fig. 4. A six-rayed variety of the same species, seen from above, the tentacles being also cut near their base.

Fig. 5. A specimen in a state of contraction, seen obliquely from above, the tentacles contracting into irregular undulations.

Fig. 6. In a state of rest, the tentacles, however, to some extent contracted, and much shorter than in Fig. 8, 11, and 12, in which they are fully developed.

Fig. 7 gives a similar aspect, only the lower margin is contracted, while in Fig. 6 it is more expanded, so that in Fig. 6 the outline is hemispherical, and in Fig. 7 more globular.

Fig. 8. A specimen in a state of contraction of its lower marign, the gelatinous disk being elongated, and the animal, the tentacles of which are in the utmost state of elongation, turning upon itself, so that the tentacles are curved in graceful arches, and the proboscis drawn in.

Fig. 9. The body has assumed a more globular appearance, the tentacles are shortened, and the proboscis hangs out, the animal moving horizontally.

Fig. 10. The hemispherical disk is somewhat elongated, the proboscis hangs out, and the tentacles are still more shortened.

Fig. 11. The six-rayed variety swimming obliquely, with its tentacles fully developed and the proboscis curved inwards.

Fig. 12. Another specimen of the common variety swimming downwards, the tentacles elongated, but not in their utmost state of elongation, the proboscis also drawn in.

Plate V.

This plate represents structural details of *Sarsia mirabilis*.

Fig. 1, 2, 3, 4, 5, 6, and 11. The muscular system chiefly is represented, in blue color, but the radiating tubes and the circular tube, as well as the proboscis, are also more or less distinctly seen; in Fig. 1, 2, 3, 4, 5, and 6, the proboscis, however, is suppressed, not to crowd the figures.

Fig. 1. The inner muscular systems; *d, d* being the main vertical bundles; *e, e, f, f*, the secondary inner vertical bundles; *g, g*, the radiating tubes; and *i*, the circular inner bundles. In this state of contraction, in which the muscles are best seen, the circular tube of the lower margin appears as a quadrangular figure, contrasting most remarkably with its circular outline in a natural position, as shown in Fig. 11.

Fig. 2. The same, seen from below, so that the sensitive bulbs, with the eye-specks and tentacles, are well seen; *d, d* represent the main vertical inner bundles; *e, e, f, f*, the secondary muscular vertical bundles; *g, g*, the lower partition; *i, i*, the inner circular bundles; *l, l*, the tentacles; and *o, o*, the accessory bundles of the vertical tubes.

Fig. 3 shows the outer muscular system; *a, a* being the main external vertical bundles; *b, b*, the secondary external vertical bundles; all of which are united above by circular fibres, as are also the secondary bundles somewhat lower down; *g, g*, radiating tubes.

Fig. 4. The same muscles, from below; *a, a* being the main external vertical bundles; *b, b*, the secondary external vertical bundles; *g, g*, the lower partition; *l, l*, the tentacles.

Fig. 5. The same parts with the internal muscular systems in a specimen of the six-rayed variety; *d, d* being the main external bundles, confounded with the main internal bundles; *e* and *f*, the secondary internal bundles; *g, g*, the lower partition.

Fig. 6. The muscular system in the utmost state of contraction, so that the outline of the animal appears four-lobed and the inner main cavity eight-lobed; *d, d* being the main external bundles; *e, e, f, f*, the secondary internal bundles.

Fig. 7. The proboscis in its connection with the central digestive cavity, the radiating tubes, the circular tube, and the tentacle; *o* being the mouth; *a*, the lower part of the proboscis; *b*, its middle part covered with eggs; and *c*, its upper part; *d*, indicating the central digestive cavity; *e*, the radiating tubes; *f*, the sensitive bulb; and *i*, the eye-speck.

Fig. 8. The proboscis in another attitude; *o* being the mouth; *a, b, c, d*, corresponding to the same letters in Fig. 7; but in this figure there are no eggs; *e*, outer coat; *i*, inner coat.

Fig. 9 gives another view of the proboscis, the middle part of which is covered with eggs.

Fig. 10 represents the same apparatus in its utmost state of contraction, the letters *o*, *a*, *b*, *c*, *d* corresponding to the same letters in Fig. 7, 8, and 9. In this state of utmost contraction, the analogy of the proboscis and central digestive cavity of Hippocrene and other naked-eyed Medusæ is very obvious.

Fig. 11. A profile view, to illustrate chiefly the connection of the vertical tubes, *e*, *e*, with the proboscis, *o*, and the circular tube, *k*, below, and also the inner vertical and circular muscular bundles, *i*, *i*; *g*, *g*, lower partition; *l*, *l*, tentacles; *m*, *m*, eye-specks.

Fig. 12. A sensitive bulb, to show its connection with the circular tube, the vertical tube, and the tentacle; *a* being the circular tube; *b*, the vertical extremity of a radiating tube; *c*, the sensitive bulb; *d*, the eye-speck; and *e*, the base of a tentacle, upon the surface of which the clusters of nettling cells are distinctly seen.

Fig. 13 gives another view of the sensitive bulb, still more enlarged, and seen somewhat from the side; *a*, being the eye-speck; *b*, the hollow tentacle, in which granules are seen moving, as in the dilatation of the horizontal circular tube, *c*, and of the vertical radiating tube, *d*.

Fig. 14 gives a front view of the sensitive bulb; *a* being the vertical tube; *b*, the eye-speck; and *c*, the hollow tentacle, in which granules are also seen.

Fig. 15 represents the termination of a tentacle.

Fig. 16 represents its middle part in a state of contraction, so that the clusters of nettling cells do not appear distinctly.

Fig. 17. Part of a tentacle elongated to the utmost, when the nettling cells appear as isolated clusters.

Plate VI. — Tiaropsis diademeta.

Fig. 1 to 8 represent various views of the whole animal. Fig. 1, 2, 6, 7, 8, are of natural size. Fig. 3, 4, 5, considerably enlarged.

Fig. 1 represents it in its utmost state of lateral expansion.

Fig. 2. Somewhat contracted round the margin, so as to give it a hemispherical shape, as is also seen in Fig. 3 and 4.

Fig. 6. Contracted at some distance from the margin.

Fig. 7. The margin being highly contracted, giving it a more globular form.

Fig. 8. The contraction is carried so far as to give it an almost quadrangular radiated appearance.

Fig. 3, 4, 5, show the natural connection of all parts, seen in profile and from above; the radiating tubes are, however, somewhat differently placed in these three figures; they agree in Fig. 4 and 5; *a*, *a* represent the ovaries and spermaries; *b*, *b*, the radiating tubes; *c*, *c*, the large eye-specks; *e*, *e*, the central digestive cavity; and *i*, *i*, the fringes of the mouth.

Fig. 9 shows the connection between the central digestive cavity and the radiating tubes; *a* being the digestive sac; *b*, the fringes of the mouth; and *c*, the ovaries hanging around the radiating tubes.

Fig. 10 represents the mouth from below, the fringes being stretched sideways.

Fig. 11 represents the same as seen from above, so that the radiating tubes are plainly visible, and upon one ray the ovaries are drawn in their normal connection.

Fig. 12. The fringes of the mouth seen in profile.

Fig. 13 shows the connection of the circular chymiferous tube with the row of marginal tentacles, and one large eye-speck.

Fig. 14 represents the connection of the central digestive cavity with the radiating tubes, the circular tube, and the lower partition, from a young specimen. The number of tentacles between a large eye-speck and a radiating tube, and between two large eye-specks, is much smaller than in adult specimens, as may be seen upon comparison with the corresponding parts of a larger specimen, Fig. 15.

Fig. 16. The bases of some marginal tentacles, and a large eye-speck, in their connection with the circular tube and the lower margin of the gelatinous disk.

Fig. 17. One of the large eye-specks; *a* being its cluster of pigment-cells; *b*, the inner row of large transparent cells; and *c*, the outer row of transparent cells.

Fig. 18 represents the contractile cells of the lower partition.

Plate VII. — Staurophora laciniata.

Fig. 1 to 11 represent natural attitudes of this remarkable species, of natural size in Fig. 1 to 8, and somewhat enlarged in Fig. 9 to 11.

Fig. 1. From the side, somewhat contracted, in a state of onward movement, the marginal tentacles being drawn together and hanging backwards.

Fig. 2. From below, the margin being folded over like four lobes.

Fig. 3. A profile view, in an attitude in which the gelatinous disk is considerably raised.

Fig. 4. From above, the lower margin being contracted inwards.

Fig. 5. In the same position, the lower margin assuming a quadrangular outline.

Fig. 6. Swimming downwards, the margin contracted in a circular outline, and the tentacles drawn inwards.

Fig. 7. The lower margin is here stretched outwards in undulating lobes, seen from below.

Fig. 8. We have here a view from above, the whole animal assuming a more quadrangular shape.

Fig. 9. Magnified view of the animal seen from above, the curled tentacles stretching outwards. Small eye-specks are seen upon their swollen bases; but what is most prominent is the central cross formed by the radiating tubes, and the extensive fringes encircling the star-shaped mouth.

Fig. 10. A profile view of the same animal, the cross being placed so that two radiating tubes appear on the right, and two on the left.

Fig. 11. Another profile of the same, the radiating tubes being placed in a different position. Two small specimens of Sarsia are caught between the fringes of the mouth in two opposite parts of its extensive cross.

Fig. 12. The central space of the mouth with four radiating furrows encircled by membranous folds.

Fig. 13 shows in a profile view the origin of the closed radiating tubes, beyond the edge of the mouth, the folds of which hang below, and some eggs above.

Fig. 14. The same region seen from below, to show how the furrow of the mouth passes into a closed radiating tube.

Fig. 15. The central part of the mouth, with its four radiating furrows.

Fig. 16. The lower margin of the animal near a radiating tube, two tentacles hanging down, one curled upon itself, and the other cut at its extremity, and two equally cut near their base, lifted up to show that the eye-specks are upon the inner surface of the tentacles.

Plate VIII.

Ideal sections of all the genera illustrated in this paper. The illustrations in all the figures correspond to each other to facilitate comparisons.

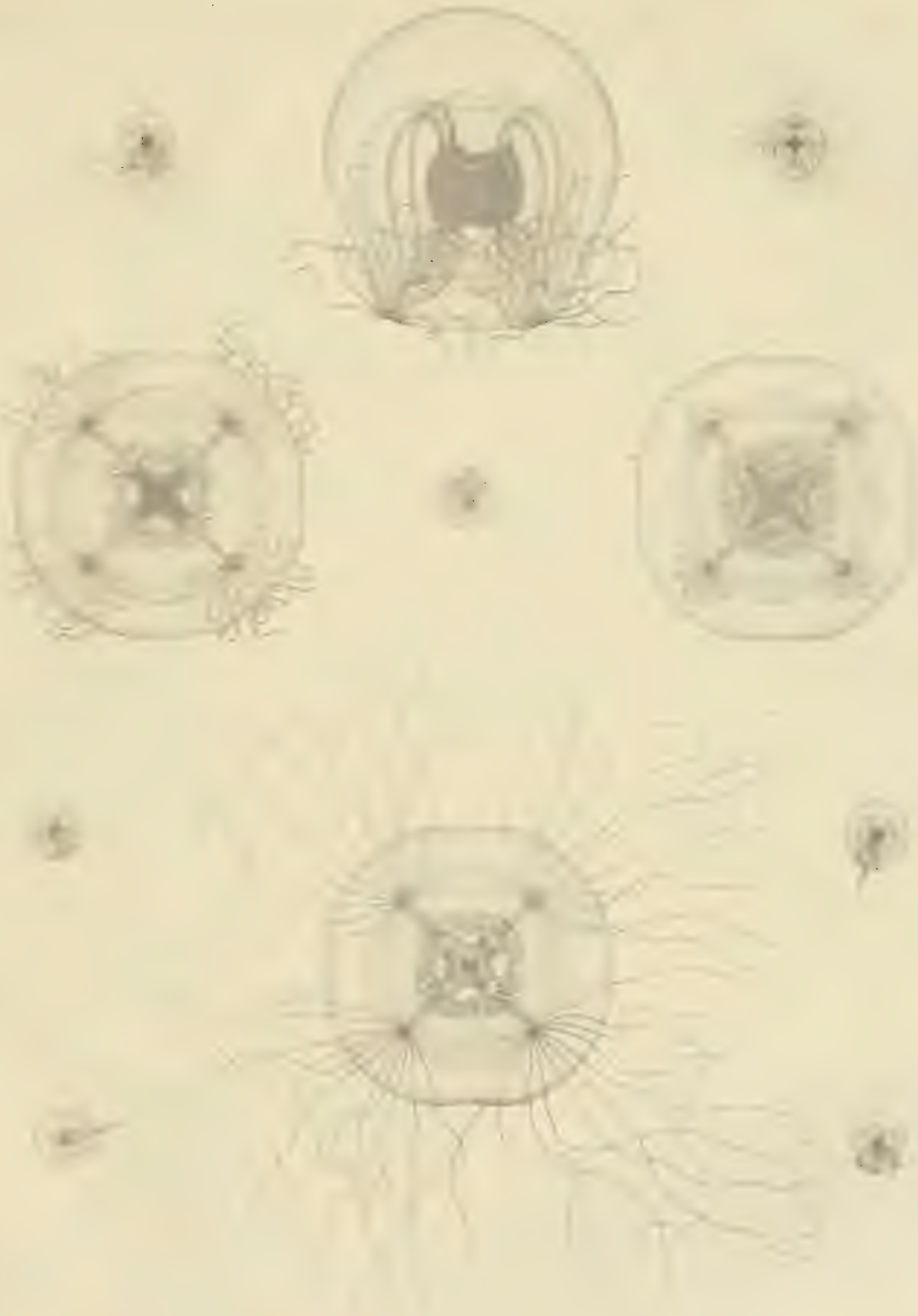
In Fig. 1 and 4, *a*, *a* represent the lower centre of the gelatinous disk; *b*, *b*, its main bulb; *c*, *c*, its lateral wall.

In Fig. 2, 3, 5, 6, 11, and 12, *a* indicates the main internal vertical bundles; *b*, the main external vertical bundles; *c*, the circular bundles; *d*, the nervous cord; *e*, the upper nervous cord; *g*, the nervous plexus; *i*, the circular tube; *h*, the tentacles; *k*, the lower partition; *t*, the vertical tubes.

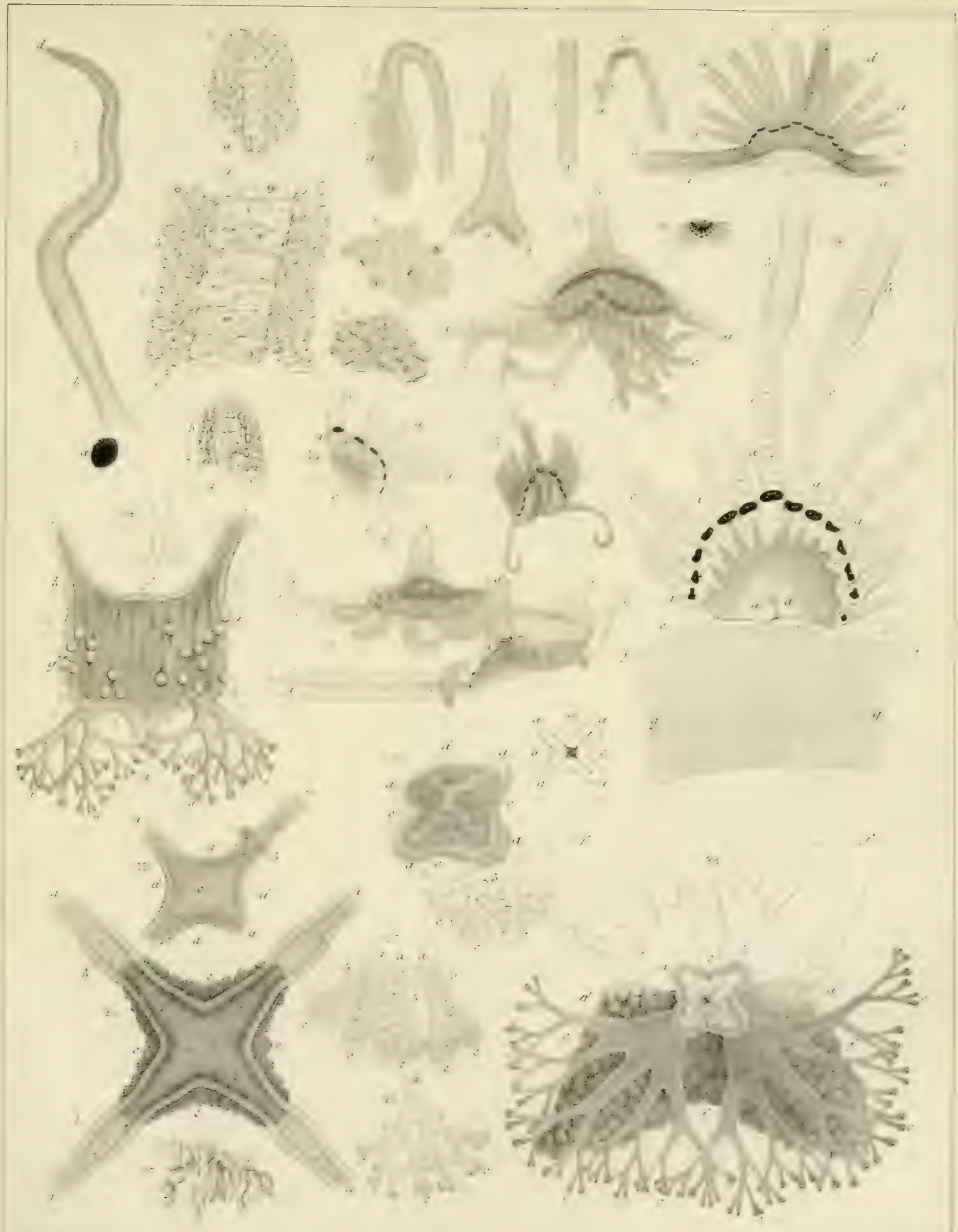
In Fig. 7 and 9, *a*, *a* indicate the inner circular muscles; *b*, *b*, the main external vertical muscles; *b'*, *b'*, the secondary vertical external muscles; *c*, *c*, the main inner vertical muscles; *c'*, *c'*, the secondary inner vertical muscles; *t*, *t*, the vertical tubes.

In Fig. 8 and 10, *a* indicates the lower partition; *b*, the nervous cord; *c*, the circular chymiferous tube; *d*, the sensitive bulb; *e*, the outer main vertical bundles; *e'*, the inner main vertical bundles; *t*, the radiating tubes.

Errata. — Page 285, line 10 from bottom, erase *f*, *f*. — P. 298, line 6 from bottom, read Fig. 6, instead of Fig. 5.



HIPPOCRENE SUPERCILIARIS Agass



F. Sorrel on stone from nat.

Tappan & Bradford's lith.

HIPPOCRENE SUPERCILIARIS Agass

HIPPOCRENE SUPERCILIARIS Agass

A. Sonrel on stone from nat.

Tappan & Bradford's Lith.

SARSIA MIRABILIS Agass.

Tappan & Bradford's lith

SARSIA MIRABILIS Agass

A. Sonrel, on stone

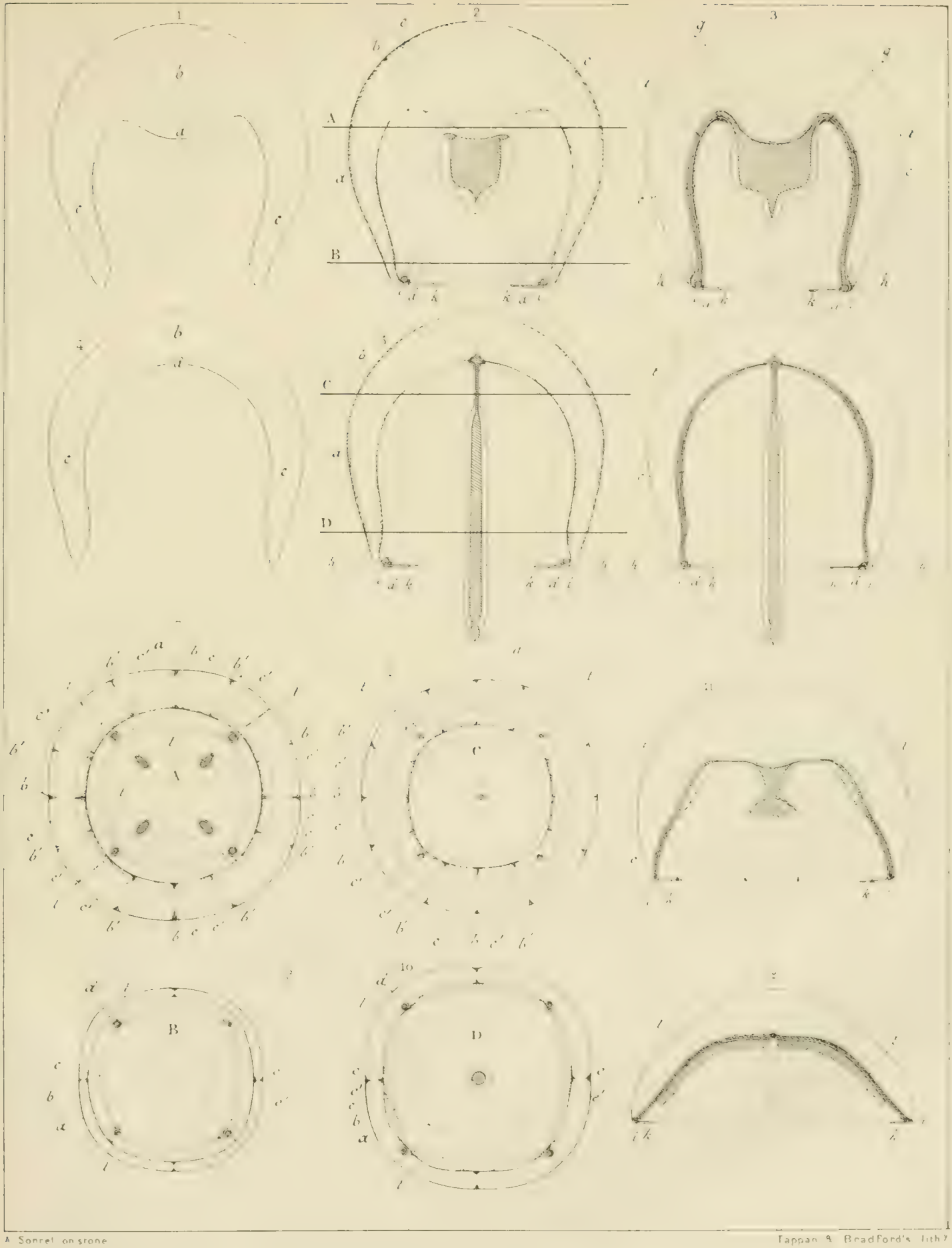
Tappan & Bradford's lith.

TIAROPSIS DIADEMATA. AGASS.

A. Sonrel on stone.

Tappan & Bradford's lith.

STAUROPHORA LACINIATA. AGASS.



A. Sonrel on stone

Tappan & Bradford's lith.

IDEAL SECTIONS.

X.

Contributions to the Natural History of the Acalephæ *of North America.*

By L. AGASSIZ.

PART II. — *On the Beroid Medusæ of the Shores of Massachusetts, in their Perfect State of Development.*

(*Communicated to the Academy, May 8th and May 29th*, 1849.)

PLEUROBRACHIA.

The character of the Beroid Medusæ is entirely different from that of the Discophoræ. Both their form and organs of locomotion give them a different appearance. The common Discoid Medusæ, setting aside the various modifications arising from marked peculiarities of their outline, move like an umbrella, which, alternately opening and shutting, would make its way under water by means of such movements. It is by contraction of the body itself, — of its mass, or rather of the muscles which pervade that mass, — that motion is produced in those animals. Not so in the Beroid Medusæ, where the whole body, more or less spherical or ovate, compact or split at one end, is kept swimming by the flapping of innumerable small oars, arranged in vertical rows, like the ribs of an orange, upon the outer surface, along which horizontal combs of little fringes move with extraordinary rapidity, forming a sort of revolving wheel. These rows are generally eight in number, extending from one point to the opposite side, like the meridians of an artificial globe. But owing to the inequalities in the motions of their vertical flappers, and their almost circular arrangement around the more or less spherical body, these animals have a somewhat rotatory motion, unless the oars move on all sides with perfect steadiness and uniformity.

There can be scarcely any thing more beautiful to behold, than such a living transparent sphere sailing through the water, running one way or another, now slowly revolving upon itself, then assuming a straight course, or retrograding, advancing, and moving sideways in all directions with equal precision and rapidity, then stopping to pause, for

a time almost immovable, with a slight waving of some of its vibrating fringes, which gentle motion easily counterbalances the difference in specific gravity between these animals and the water in which they live. So Pleurobrachia may appear at times, and so it even does appear when it moves in its state of contraction. But generally, when active, it hangs out a pair of most remarkable appendages, the structure and length and contractility of which are equally surprising, and exceed, in wonderful adaptation, all I have ever known among animal structures. Two apparently simple irregular, unequal threads will hang out from two opposite points on the sides of the sphere. Presently they will elongate, equal in length the diameter of the sphere, presently surpass it, increase to two, three, five, ten, twenty times the diameter of the body, and more and more; so much so, that it would seem as if these threads had the power of endless extension and development. But as they lengthen, they appear more complicated. From one of their sides other delicate threads shoot out like fringes, forming a row of beards, like those of the most elegant ostrich feather, and each of these threads itself elongates till it equals in length the diameter of the whole body, and bends in the most graceful curves. These two long streamers, stretching out in straight or undulating lines, sometimes parallel, then diverging, follow the motions of the main sphere, being carried on with it in all its movements. Upon considering this wonderful being, one is at a loss which most to admire, the elegance and complication of that structure, or the delicacy of the colors and hues, which, with the freshness of the morning dew upon the rose, shine from its whole surface. Like a planet round its sun, or, more exactly, like the comet with its magic tail, our little animal moves in its element, as those larger bodies revolve in space, but unlike them, and to our admiration, it moves freely in all directions; and nothing can be more attractive than to watch such a little living comet, as it darts with its tail in undetermined ways, and revolves upon itself, unfolding and bending its appendages with equal ease and elegance, at times allowing them to float for their whole length, at times shortening them in quick contractions, and causing them to disappear suddenly, then dropping them, as it were, from its surface, so that they seem to fall entirely away, till, lengthened to the utmost, they again follow the direction of the body to which they are attached, and with which the connection that regulates their movements seems as mysterious as the changes are extraordinary and unexpected. For hours and hours I have sat before them and watched their movements, and have never been tired of admiring their graceful undulations. And though I have found contractile fibres in these thin threads, showing that these movements are of a muscular nature, it is still a unique fact in the organization of animal bodies, that by means of muscular action parts may be elongated and contracted

to such extraordinary and extensive limits. And what is so surprising is not so much the sudden powerful contraction which brings within the compact limits of a pin's head the whole mass of these tentacles, that a moment before were floating so elegantly through such a great extent in the water, as the relaxation, which takes place in an absolutely passive manner; for when watching them, we are suddenly struck with astonishment on finding that the tentacle which we expected to see drop to the bottom of the jar is still in organic connection with the body from which it hangs. Plate I. represents some few of the attitudes of Pleurobrachia in its various movements; but I cannot find words to describe all the beautiful changes which the parts thus in motion assume in different attitudes. At one moment, the threads, when contracted, seem nodose; next, when more elongated, these knots are stretched into the appearance of a spiral; next, the spiral, elongating, assumes the appearance of a straight or waving line. But it is especially in the successive appearances of the lateral fringes arising from the main thread, that the most extraordinary diversity is displayed. Not only are they stretched under all possible angles from the main stem, at times seeming perpendicular to it, or bent more or less in the same direction, and again as if combed into one mass; but a moment afterwards every thread seems to be curled or waving, the main thread being straight or undulating; then the shorter threads will be stretched straight for some distance, and then suddenly bent at various angles upon themselves, and perhaps repeat such zigzags several times, or they will be stretched in one direction, and bent at various angles in the plane of another direction; then they will be coiled up from the tip, and remain hanging like pearls suspended by a delicate thread to the main stem, or, like a broken whip, be bent in an acute angle upon themselves, with as stiff an appearance as if the whole were made up of wires; and, to complete the wonder, a part of the length of the main thread will assume one appearance, and another part another, and pass from one into the other in the quickest possible succession; so that I can truly say, I have not known in the animal kingdom an organism exhibiting more sudden changes, and presenting more diversified and beautiful images, the action, meanwhile, being produced in such a way as hardly to be understood. For when expanded, these threads resemble rather a delicate fabric spun with the finest spider's thread, at times brought close together, combed in one direction without entangling, next stretched apart, and preserving in this evolution the most perfect parallelism among themselves, and at no time, and under no circumstances, confusing the fringes of the two threads; — they may cross each other, they may be apparently entangled throughout their length, but let the animal suddenly con-

tract, and all these innumerable interwoven fringes unfold, contract, and disappear, reduced, as it were, to one little drop of most elastic India-rubber. Week after week I have preserved these animals alive, and have never been tired of comparing again and again their changes in these thousandfold developments of their appendages. I have called together those who felt the slightest curiosity for such objects, to witness these phenomena, and have found them all interested to the utmost; and if I have any thing to regret, it is not the time lost in this contemplation, — for the more I became familiar with the sight, the more I was compelled to admire its beauty, and to contrast with the new forms presenting themselves before my eyes those different states with which I had been familiar before, — but it is the circumstance that the duration of their life is limited to a few months, and that I could not have a larger number of philosophic observers to contemplate with me these marvels, and that the time was too short to trace all the details of their structure microscopically; although I am aware that I have noticed many particulars which had been unnoticed before.

The chief difficulty in the comparative study of the different genera of this family arises from the circumstance, that they move permanently in different directions, some having the mouth naturally turned upwards, and others downwards; and that, from not having perceived this difference, the parts placed in opposite positions have been compared with each other in the different genera, which on that account require a complete revision of their characteristics.

The type under consideration, for which I retain the name of Pleurobrachia, as the most ancient applied to species of this particular conformation, is one of those which is deprived of peripheric lobes, that is to say, in which the gelatinous body is undivided, and the mouth constantly turned upwards or forwards when in motion; while the genus Bolina, to which I shall next call attention, is one of those in which one extremity of the sphere is split into two lobes, between which the mouth is situated, and in which this opening is almost constantly turned downwards when the animal is moving, though sometimes, when the animal is at rest, it turns in the opposite direction, opening widely its two lobes. It will be obvious how great mistakes may arise from comparing two animals constructed upon the same plan, but kept in a reversed position when contrasted. The difficulty of a thorough comparison of all the genera of this family is further increased by the circumstance, that genera without lobes or with slight indentations move naturally in the same position as Bolina; or in a position the inverse of that of Pleurobrachia. Such is the case, for instance, with Alcinoe, while Dellechiaja, with its very complicated lobes, moves in the position of Pleurobrachia.

Unhappily, all these animals have been figured without reference to the natural position in which they should be compared, and, no allusion to these prominent differences being made, it is hardly possible to reconcile the descriptions of one author with those of another.

The genus Pleurobrachia is limited to those species of Beroid Medusæ in which the body is nearly spherical or slightly elongated, the locomotive fringes extending from the margin of the mouth all round the sphere, in eight vertical rows, towards the opposite centre, where they approach very near to each other. This genus differs from Cydippe chiefly in the extensive development of the rows of locomotive fringes, which, in the latter, do not extend below two thirds of the whole height.

I know at present only two species of this genus sufficiently well characterized to be recognized as distinct species; one, the *Pleurobrachia* common on the northern shores of Europe, and the other that *Pileus* which I have observed on the eastern shores of the Northern United States, and for which I propose the name of *Pleurobrachia rhododactyla*, from its long, light rosy-colored tentacles.

Though almost spherical, this species is slightly compressed in the vertical plane of the two tentacles, so that one diameter, at right angles with the base of the tentacles, is somewhat shorter than that which would pass through their points of attachment.

As it is of great importance to the full understanding of the internal structure of this animal, and the correct appreciation of all its organs, to form a correct idea of their respective location, I feel compelled to enter into some tedious details respecting this slight variation from the spherical form; for though scarcely appreciable, it has a direct connection with the bearing of all the organs, which, upon close examination, are found to preserve throughout a constant relation to this apparently insignificant difference between the diameters; so much so, that these globular animals are truly bilateral in the arrangement of all their parts.

In the first place, the mouth is split transversely, and there is upon the opposite pole of the sphere an oblong, narrow, circumscribed area, placed also in the same direction, transversely to the longer diameter. So that the two tentacles with their bases are placed at right angles with the transverse split of the mouth and the opposite transverse area, the former being in the longer diameter, the mouth and the area in the shorter. The rows of movable fringes alternate, two and two, with these four radiating directions. So that there are four rows on one side of the plane passing through the tentacles, and four on the other; and also four on one side of the plane passing through the mouth and the opposite area, and four on the other,

no one being placed either in the prolongation of the mouth, or in that of the bases of the tentacles (Plates III. and IV. Fig. 3 and 4).

Again, owing to the slight flatness of the body, the four rows of fringes have their upper and lower arms bending in a somewhat different manner, so that there are two pairs perfectly parallel with each other along the prominent side, inclosing the base of the tentacles, which are perfectly equal, and two other pairs along the flattened side, inclosing the prolongation of the angles of the mouth and the transverse projections of the opposite area. The consequence of this arrangement is, that each segment of the body has two unequal rows of locomotive fringes placed in a corresponding symmetrical manner opposite each other, side by side, or crosswise.

Having thus ascertained that the body of this animal is not truly circular or spherical, and that there is a medial axis, with reference to which the arrangement of parts is regulated, their four planes meeting at right angles, one of which passes through the longitudinal diameter of the mouth and the corresponding diameter of the opposite area, and another through the bases of the tentacles, which are prolonged into the interior of the body, the question at once arises how we should consider these rays; whether the mouth should be placed upwards or downwards, or whether it should be considered as the anterior extremity. As with the other Medusæ, whatever view we take of the subject, when we compare these animals with either Polypi or Echinoderms to ascertain their homologies, we must, as a matter of necessity, bring them all into the same respective position, and contrast the arrangement of their parts in their mutual correspondence. There is, therefore, no difficulty about this point, inasmuch as the mouth is made in every case the central point of comparison. But it has been ascertained that Polypi, though absolutely radiated animals, have in most of their types, if not in all, a rudimentary indication of a longitudinal axis in the oblong form of their mouth, which is the first indication in the animal kingdom of a bilateral symmetry, occurring even among the lowest Radiata, while in Echinoderms it rises higher and higher, and becomes so prominent in Spatangoids as to influence, not only the general form, but even the number and arrangement of the internal parts, and the length and special development of the external appendages and the ambulacral rows.

The class of Acalephæ, which is intermediate between those of Polypi and Echinoderms, holds in these respects also an intermediate position. Here we have a slightly compressed body and an oblong mouth. But the mouth opens in a direction transverse to the elongation of the body. The question therefore is, Does the mouth, with the plane which passes through the mouth and the opposite area, indicate the

length of the axis of the body, and divide it into a right and left half, and are therefore the tentacles lateral appendages, one on the right side and the other on the left side, as we should consider them if we place the axis of the mouth in the same direction as the axis of the mouth in Polypi, or have we to consider the tentacles as arranged along the longitudinal axis, one on the anterior and the other on the posterior extremity? And in that case, is the split of the mouth rather the first indication of an upper and lower lip, — as we should consider them were we to compare the transverse position of the mouth with the position this opening assumes in the oblong symmetrical Echinoderms, in which the bilateral symmetry has been made prominent, — or have we to view also the indication of bilateral symmetry among Polypi as a tendency to such an arrangement between the two lips? I think I can be positive in the case of Polypi; for in Actinia, as well as in Astrangia, the oblong fold of the mouth is unequal in its two angles; and it were to suppose the right and left angle of the mouth to be unequal, and the upper and lower lip to be symmetrical, if we do not agree to consider this split as running in the longitudinal axis. And that it indicates really a longitudinal axis is shown by the circumstance, that fecal matters are discharged along the rounded angle of the oblong mouth, opposite to which there is in many Polypi a tentacle of a peculiar form. But this being the case, are there reasons to view Pleurobrachia in a different light? Are they really in their arrangement more nearly related to Echinoderms than to Polypi? I hardly believe it; for, as the mouth is transverse in so many Echini, their anterior and posterior extremities always differ more and more, in the same proportion that the bilateral symmetry is increased and made more prominent. It seems to me, therefore, more natural to compare Pleurobrachia with the other Radiata in a position in which the split of the mouth will indicate the antero-posterior diameter, even though the diameter considered as the transverse be thus greater than the longitudinal. This is, however, not the only instance of this case in the animal kingdom. In many Mollusca of the class Acephala, in the family of Cardiacea and Brachiopoda, we have numbers of genera and species in which the longitudinal axis is shorter than the transverse. And though the vertical rows of locomotive fringes may remind us of the ambulacra of Echinoderms, I still hold that such a position as I assign to them is in more direct accordance with the general progress of symmetry among Radiata than the reverse. The first tendency beyond the pure radiated arrangement which is introduced among them is to a symmetrical disposition and parity between right and left, even if the anterior and posterior extremities be marked only by this lateral symmetry, and are not made to differ from each other. Next, the two ends of the antero-posterior diameter are made to

differ, and this we see introduced only among the higher Echinoderms. For, though bilateral symmetry can be recognized among star-fishes and Echini proper, their anterior row does not yet differ, and the first appearance of such a difference is introduced in the family of Clypeastri, and more developed in Spatangi. If, therefore, the Echinoderms, which as a whole rank above Medusæ, still retain so much of the radiated type, and the bilateral symmetry is developed in them among so many of their types solely in the perfect symmetry of right and left, without a difference between forwards and backwards, why should we expect this still earlier in the class of Acalephæ, especially when we are able to refer this type so easily to that of Polypi? I assume, therefore, decidedly, that the diameter which corresponds to the split of the mouth indicates the longitudinal axis, and shall, in the following pages, describe all parts with reference to this view. I thus consider the halves of the body which would be divided by a plane passing through the split of the mouth, and through the opposite oblong area, as the right and left halves of this animal, and therefore the tentacles as being placed right and left. But I must for the present leave it doubtful which is right and which is left; for the sides are so completely identical, the two angles of the mouth are so absolutely equal, the prominent projections of the opposite area so uniform, as to afford no indication upon this point. This is a very remarkable circumstance to occur in a class intermediate between two others, in which the anterior and posterior margin can be fully ascertained in the radiated arrangement, even in the Polypi, though they rank lower. Is there, however, not a compensation for this difference in the greater symmetry of the two sides, as there are only four rays upon which the development of the animal takes place in Medusæ, while in other Radiata the numbers are odd? But, again, among Polypi, in the family of Halcyonoids we have the tentacles strictly in pairs, and here, also, the oblong opening of the mouth passes between the four pairs of tentacles, in such a manner as to render the anterior and posterior extremities absolutely equal. In this respect, Alcyonium would agree with Pleurobrachia, and justify the position I have ascribed to its bilateral symmetry. In another great type of the animal kingdom, we have a similar, though inverse case, in the family of Brachiopods, in which the anterior and posterior extremities are perfectly symmetrical, but in which the right and left are widely different, and a pair of tentacles which, in some respects, might be compared to the tentacles of Pleurobrachia, placed forwards and backwards. So that, if we were justified in taking our standard of comparison from the arrangement of parts in another type, there could be no hesitation in considering the greater diameter of Pleurobrachia as the antero-posterior diameter, and one of the tentacles as the anterior and the other as the posterior, and the mouth

as transverse. But here then right and left would remain doubtful. For the reason above alluded to, I have, therefore, no hesitation in tracing my comparisons through all the classes of Radiata, and introduce here the Brachiopods only that they may be remembered in this connection. The parts already mentioned in a general way are not the only ones which have reference to the bilateral arrangement. The tentacles arise in two sacs, extending inwards in a vertical direction towards the opposite side of the body, and reaching a point about as far below the higher centre of the animal as the point from which the tentacles issue is from the lower centre. These sacs are connected with another very large sac, giving out two wide hollow forks in opposite directions in the transverse diameter of the body, which branch at right angles parallel to the longitudinal diameter, and again give out each a branch at right angles, that is to say, parallel to the transverse diameter, thus forming the eight forks of eight hollow tubes, following for their whole length the inner surfaces of the eight vertical rows of locomotive fringes. The position of this complicated system, therefore, presents a regular symmetry, two main trunks penetrating symmetrically right and left from the central cavity, and branching in such a manner as to reach on each side with four arms the four vertical rows of locomotive fringes, and also to supply the sac from which the tentacles arise. This cavity is full of liquid, which is in constant movement by the agency of vibratory cilia, but also under the influence of a regular pulsation of the system in the two halves of the body, which alternate in their contraction and dilatation; so that at one time the fluid moves, to a considerable extent, from one side to the other, and next returns by the contraction of the opposite side through the same tube in the opposite direction, presenting something similar to what exists in Salpa, under circumstances differing considerably, however, as will be shown presently. The point to which I now wish especially to invite attention is the circumstance, that there is a large central cavity branching in a very symmetrical way in the right and left parts of the body, and undergoing a rhythmic movement of contraction and dilatation, alternating between the two sides. This cavity, which I shall call the chymiferous cavity, is not to be mistaken for the digestive cavity, which constitutes a sac within it hanging downwards from the mouth for about two thirds of the length of the animal, but which communicates with it in the same manner as the digestive cavity of Actinia communicates with the main cavity of the body. This chymiferous cavity finally has two apertures, by which it communicates with the surrounding water, and through which it discharges the refuse chyme. These apertures are placed in a symmetrical position on the two sides of the area opposite the mouth near its centre, obliquely opposite each other, so that one is in the anterior half upon one side of the body, the other in

the posterior half upon the other side. These openings are generally shut, but they open at intervals to discharge the fecal matters, and are afterwards instantaneously shut again. It is very difficult to catch these movements, and even after I had seen them open and shut, I have frequently watched days for them without observing a repetition of the operation, which I have, however, seen so many times now, that I entertain no doubt respecting the position of these openings, and their natural function. Moreover, balls of fecal matters will almost constantly be seen floating with a rotating motion below these apertures.

This sketch gives as yet but a slight, very incomplete, and superficial idea of the remarkable complication of structure which may be observed in these animals. But such a preliminary illustration was necessary before undertaking a minute description of all parts and their natural relations, and before alluding to these details I would request the reader to bear the following points in mind; — that Pleurobrachia is not strictly spherical, nor even strictly circular, in its somewhat elongated form; that there is a longitudinal axis, which passes through the mouth and the area opposite; that the tentacles are in the longer axis, at right angles with the fissure of the mouth; that the digestive cavity hangs in a large circulatory cavity branching symmetrically in the right and left halves of the body, the branches, eight in number, reaching the eight vertical rows of locomotive fringes, two other branches providing the sacs from which the tentacles issue, and two others following the walls of the digestive cavity, these four latter rising from the main lateral stems of the central cavity along the transverse diameter, the forks supplying the locomotive fringes, on the contrary, branching first parallel to the longitudinal diameter, and emitting each another fork parallel to the transverse diameter; so that all parts have a precise geometrical relation to each other; and finally, that the right half of this system alternates in its contractions with the left half.

In the special investigation of the minute structure of the different systems of organs developed in these animals, it will be better to proceed in such an order as will assist us in the understanding of all the other systems, rather than upon a physiological principle.

Though the form is apparently well determined and regular, even superficial investigation will satisfy the observer that it is constantly changing within more extensive limits than the appearances would lead him to suspect. In the first place, the apparently spherical form is not only frequently altered into an ovate by the elongation of the mass, but it even assumes, at times, a form rather cylindrical than ovate, especially on the side of the mouth, by the extensive dilatation of this opening. The changes which the mouth assumes in its outlines are very extensive and frequent. When shut, and

completely shut, it disappears almost entirely, and its position is scarcely marked by any thing more than an indistinct outline, towards which the upper ends of the rows of locomotive fringes converge. When half-way open, or while opening, it assumes an oval form, like a fissure across the body, which becomes gradually more and more elongated, then widens, and finally expands into an ample circular funnel-shaped depression. (Plate II. Fig. 1, 2, 5, 10, and 11; Plate III. Fig. 3; Plate IV. Fig. 3 and 5; Plate V. Fig. 3, 4, 5, and 6.) These movements are rather slow, and may be compared to the undulations of a slug or snail adapting its mouth to the form of its food. The changes in Pleurobrachia, however, do not seem to be called forth by the approach of food, but are rather the result of a natural disposition in this animal to be in an attitude ready to seize upon its prey. The movements are regulated by powerful bundles of muscular fibres arranged in a very regular manner. At first it would seem as if the whole mass of the body were equally gelatinous and transparent. But upon close examination, and even under a slight magnifying power, the large development of muscular fibres throughout these bodies is readily seen, and explains fully the easy movements of these animals, and the readiness with which they change their form.

The arrangement of these muscular fibres being most easily understood in their connection with the vertical rows of locomotive fringes, and the form and position of the circumscribed area opposite the mouth, I shall begin this illustration by some details upon that apparatus. The vertical rows of locomotive fringes (Plates I. to IV.) are entirely superficial. The fringes themselves (Plate II. Fig. 6) seem to be modified epithelial cells, for whenever, in the progress of decomposition, the epithelium is dissolved in the space between the fringes, it is easy to trace the decomposition of the tissue into this apparatus, even where the muscular fibres immediately below remain unaffected. Each vertical row consists of a great number of isolated, transverse, comb-like fringes, placed one above the other, and movable, either isolately, or in regular succession, or simultaneously. Each comb consists of a large number of thread-like bristles, slightly arched upwards and downwards, of which the middle ones are the longest, tapering gradually sideways, so that the combs are, properly speaking, crescent-shaped, with a straight base, the teeth or fringes of which are movable in quick vibrations, up and down, independently in each comb, and even independently to some degree in each portion of the same comb, as the middle fringes may be seen to move when the lateral are motionless, and *vice versâ*. But generally all the fringes of one comb act simultaneously; but the motion in all the many combs of one row is successive, so that, when the combs are very active, they seem like waves moving up and down in rapid succession along each vertical row, or like the waving spikes in a cornfield agitated by

the wind. Again, the undulations of the different rows are independent; sometimes all the rows playing at the same time, at other times parts of the rows, or parts of each row, or parts of some rows, playing independently.

I have been unable to ascertain what is the structure of the fringes themselves. They seem to be stiff, and nevertheless they are too soft to be gathered for chemical analysis. They must be decidedly of a peculiar tissue, for their appearance is quite peculiar, and does not resemble that of the other tissues. The number of teeth or fringes in one of the larger combs may be about fifty, but they are not equally numerous through all the combs in one vertical row. The combs in the upper parts and in the lower parts of each row, nearer the mouth and the area opposite, are gradually shorter and shorter, and contain fewer and shorter fringes, the largest being about the middle of the vertical height. They terminate rather abruptly above, and at a greater distance from the centre than below, where they are naturally prolonged towards the central eye-speck; if the black tubercle in the centre of the circumscribed area opposite the mouth is really to be considered as an eye-speck.

The movements of these fringes seem at first to be identical with those of vibrating cilia; and one might be tempted to suppose that these locomotive fringes are formed by a row of compressed vibrating cells, arranged in such a manner as to bring their cilia in one row, and the cells themselves in such superposition above each other as to form vertical series. But the cilia or fringes are far larger than any vibrating cilia ever described, and their motion shows distinctly that they are under the voluntary control of the animal; for their movements are neither incessant nor constantly equal. They are at times accelerated or retarded, entirely stopped and resumed at shorter or longer intervals; so that the evidence of their voluntary movement is as full as can be, and, indeed, the structure which determines the movements is the same as in all cases of voluntary motion. A regular muscular apparatus can be traced along the base of each comb, muscular fibres forming a regular row above and below the base of the fringes, by the repeated contractions of which the fringes are moved up and down like flappers, in quick succession. But notwithstanding this muscular apparatus, which may be compared to a pennate muscle, the axis of which would constitute the point of insertion of the fringes, and thus control their movements up and down, it is hardly possible to refrain from the idea that these fringes are, after all, in some way or other, connected with vibratory cilia, — that they are vibratory cilia on a gigantic scale. And I do not see why there should be nowhere in the animal kingdom a transition between a particular arrangement of muscles moving independent appendages, and the structure of a ciliated cell regulating the motions of its own vibrating fringes. And if this

view is natural, it will probably be found that the vibrating locomotive fringes of Pleurobrachia are, among the many complications of animal structure, precisely that step in their development where the complication of the isolated cilia has reached its extreme, and has been made the foundation of a higher stage of development, in which the parts, which, in the primitive cell, were simply structural complications, assume an independent existence, developed by the growth of new cells.

Fully to understand the character of the vertical rows of locomotive fringes, it should be borne in mind that they are connected for their whole length with vascular tubes following the same course (Plate III. Fig. 1 to 4), and which arise from the great central chymiferous cavity. This intimate connection leads naturally to the supposition that, besides their functions as locomotive organs, the vertical rows of fringes are in some way connected with respiratory functions, and that there is between these two systems the same natural physiological connection which exists in Echinoderms between the inner branchiæ and the ambulacral tubes; or in Worms, between the respiratory vesicles and the locomotive bristles.

The circulation of fluids, and the respiratory movements connected with this circulation, are almost throughout the animal kingdom in direct communication with locomotion, even in the higher animals. Among Polypi the dilatations and contractions of the body renew constantly the water which fills their cavity, and provide them with a fresh supply of aerated water. The same is the case among Medusæ. For even where there is no distinct individualized system of respiratory organs, it is obvious that a constant renewal of the surrounding medium, by means of which oxygenation takes place, is an essential condition for the maintenance of life; and where there are no special organs adapted to this purpose, the main movements of the body supply the deficiency. The water-pores in Echinoderms, through which their main cavity is constantly filled with fresh sea-water, undoubtedly perform a similar office. Again, among Mollusca, respiration and locomotion are still more intimately connected; but in a manner which differs decidedly from what we observe in higher animals. For there, by the dilatation and contraction of the respiratory cavities and the circulation of the blood through the respiratory organs, the body is amply supplied. But unless Acephala open their valves, unless they expand and contract alternately the whole body, the supply of fresh aerated water must be much less; and I doubt whether oysters and clams could be kept alive if their valves were shut constantly by pressure, and muscular motion, contraction and expansion of the large bundles which preside chiefly over locomotion, were prevented from coming into play in aid of the vibratory cilia of the mantle and gills. The manner in which the respiratory cavity is shut in so many Gasteropods,

unless the fleshy parts are fully expanded, shows plainly that here again there is an intimate connection between respiratory movements and locomotion. In Cephalopoda this is still plainer, for, from the form of the respiratory cavities, from the disposition of the sacs in which the gills are placed, we can easily infer that the contractions and dilatations of these sacs, by which the water is renewed, must afford a material mechanical assistance in the progress of locomotion. Again, throughout the type of Articulata, this connection is most intimate, the respiratory organs being directly connected with the locomotive appendages, forming, indeed, parts of the various kinds of oars, fins, legs, and chewing appendages, by which the principal motions of the body are sustained. Not a joint can be moved here without influencing respiration, and, again, the expansion and contraction of the respiratory cavities, the filling of the respiratory vesicles, or the large circulatory sacs connected with the gills or fins, and the introduction of air into the tracheal tubes, must, in their turn, influence locomotion. And it were a subject well worthy of the attention of physiologists, to trace more minutely this double connection throughout the animal kingdom. Perhaps the type of Articulata is best adapted to make a beginning in these investigations. For among them, in the Crustacea, for instance, the chewing of the food itself is directly connected with the process of respiration. The motion of the jaws aids in forming and maintaining a regular current of water along the gills through the respiratory cavities, and even when otherwise not employed, the jaws are kept in motion in some degree to assist respiration. And it can hardly be doubted that the process of respiration also materially aids the insects in their flight, and that the state of expansion or contraction of the respiratory cavities is very different in the state of repose, or during flight. While watching locusts, I have often been struck with the state of wide expansion of their abdomen at the moment they start, and with the collapsed state of the whole body soon after they have alighted, which is even so great as to prevent their rising again immediately when chased.

Again, among Vertebrata, we find in fishes that the respiratory movements — the lifting and shutting of the operculum, the filling and emptying of the branchial cavity — aid the fish in slowly progressing; so much so, that when resting upon the bottom of a glass jar, apparently immovable, these animals are at times suddenly propelled forward under the action of a powerful occasional contraction of the branchial cavity, even if the ordinary locomotive organs, the tail and fins, remain absolutely quiet. How close a connection exists between locomotion and respiration in the Ichthyoid Batrachians, I have often had occasion to witness in a Proteus kept in confinement, in which the gills grew gradually paler and paler if the animal was absolutely motionless, but would instantly be

filled with a large quantity of blood, and appear intensely red, after some violent motion. It might be objected, that this is a mere influence of locomotion upon circulation; but if there were not this natural disposition in all locomotion to influence the process of respiration more than any other system, why should not the blood, when such powerful motions take place, be accumulated in any other part of the body, — for instance, in the tail, which is the very cause of the motion, — rather than in the gills? In birds the extensive development of the lungs, the prolongation of air-sacs into the abdominal cavity, the wings, and the sternum, in those most remarkable for their power of flight, plainly indicate again the most strict connection between locomotion and respiration, though the nature of this connection be perhaps different from that which is observed in the lower classes. Nevertheless, it exists and can be traced to a very remarkable extent. We cannot fail to trace, also, similar relations among Mammalia, though here the influence between the two functions is not so direct. However, it must be acknowledged that it is extensive enough, when we consider how the aquatic types have to accommodate all their movements to the wants of the system for atmospheric air, and remain constantly within reach of the surface, in order to be able to return to it in a short time. How much the breathing is affected by violent movements is so well known to every one, that the existence of accessory muscles of respiration in Mammalia, the antagonism between the pectoral and abdominal muscles and the diaphragm, the use of belts by athletes in running, leaping, or wrestling, need hardly to be further mentioned as evidence of this mutual relation. Of course, in animals in which all the functions have reached a great degree of independence, they are no longer subservient to each other to such a degree as they were in the lower types; but even the unpleasant influence which excessive exercise of the locomotive power has upon respiration in the higher animals shows the intimate relation which prevails in the plan of organization.

One peculiarity which might be mentioned as indicating a further connection between locomotion and respiration, if the vertical rows of locomotive fringes are at all connected with respiration, is the circumstance that they serve, for their whole extent, as points of attachment for the muscular system, as we shall see presently when describing the contractile tissue. This connection, also, may remind us of the connection which exists in Vertebrata between the anterior limbs and the chest.

When examining the structure of the vertical rows of locomotive fringes, we encounter considerable difficulties, to which I would call special attention, for the benefit of those who may have an opportunity to repeat these investigations. The best way to study their peculiar structure is to cut off from the body a portion of the row, say three or four transverse combs, and to bring them separately under the

microscope. But then the fringes lie flat, and the tips of each upper comb cover the bases of the lower, so that their insertion connot be well understood unless an upper comb be entirely removed, as in Plate II. Fig. 6. The connection of the chymiferous tubes with these vertical rows of locomotive fringes may be no obstacle in the way of their study in their living, active condition, for then they are so distended and so full of fluid as rather to facilitate their study, as they appear like a transparent basis through which the external appendages are examined with great advantage. But when pieces are separated from the body, the tubes collapse, and contract so much as to form a narrow erect hose about the middle of the vertical rows, which I had for a long time taken for a particular organ, until I ascertained, by repeated investigations, that it was the chymiferous tube empty and contracted. In Plate II. Fig. 6, the outlines of this chymiferous tube are drawn in two different stages of contraction, *a* and *a* representing its outline when half empty; *b*, *b*, when fully contracted. Again, vertical muscular fibres, and others crossing them at various angles, near the margin of the locomotive rows, may interfere with the study of their fringes, before one is fully acquainted with the subject. All these circumstances should be particularly kept in mind, when examining the muscular fibres of the base of the fringes, which act in moving them up and down, and which belong in their transverse rows to the isolated combs proper. These are best seen from the anterior surface of the rows, when a thin slice is cut in a vertical direction, and the combs themselves are placed upon the objective table with their base turned upwards. Finally, there are about this region other organs, the nature of which it has not been in my power to recognize, though they are constantly seen between the locomotive combs, alternating regularly with them, and placed about the third of their width. I allude to minute tubercles or ganglion-like swellings (Plate II. Fig. 6, 7, and 9, *o*, *o*), so small as to be, perhaps, simply isolated cells of a special character, but which, in the midst of the tissues, I have never been able fully to isolate. There are constantly two of them, or a pair, placed symmetrically, at equal distances between the single combs. Other swellings not so constant in their appearance occur in the middle line (*c*, *c*). These swellings seem to be united by a vertical thread; but this thread, as represented in Fig. 9, may be a rudiment or a fold of the contracted chymiferous tube, as I never could find it equal in appearance in two specimens. The swellings in this line may be particles of the harder contents of the chymiferous tubes, accumulating in the intervals of the combs, and forming little balls, when the tube is finally completely contracted. But whatever may be the real nature of these bodies, those which occur regularly in pairs are certainly of a different nature; for I have frequently seen distinct threads, or fibres, connected with them; sometimes, as in Fig. 6,

arising at right angles with the vertical row, and extending sideways; at times diverging in four directions, as in Fig. 7; and at times the two kinds of fibres, though less regular, would appear in connection with them, as in Fig. 9. Whether these swellings, and the threads arising from them, are sensitive ganglia, sending out nervous threads, or whether their appearance, which is subject to so many irregularities, is the result of the contraction, and perhaps of the commencing decomposition, of numerous muscular fibres, lining the inner surface of the vertical rows of locomotive fringes, must remain doubtful. I should say, however, that I have never been able to discover these parts in the living animal, though they are readily found upon slices cut from it, often immediately after their removal. The appearance I noticed in the surface of the body between the combs, when kept apart, was always similar to what is represented in Fig. 8, where muscular fibres crossing each other in various directions were chiefly visible; and, below, were granules floating through the chymiferous tube, accumulating generally to a great amount in the centre (*a*), — owing, no doubt, to the greater diameter of the tube when seen in such a position, — and apparently fewer towards its margin (*b*), where the outline appears as a double line. But the great transparency of all these parts makes it exceedingly difficult to arrive at any precise conclusion, even with regard to their respective position.

With the spherical form characteristic of the family of Beroe, the general arrangement of the muscular bundles is also somewhat modified, though regulated by the same principle which prevails in the arrangement of the muscles in the Discoid Medusæ. Here, also, we have vertical bundles and circular ones, but, owing to the spherical form of the body, these extend all round the sphere from one pole to the other, like the meridians and parallels of an artificial globe, modified in the details of their arrangement by the form and extent of the mouth, by the disposition of the area opposite to it, and by the width and extent of the vertical rows of locomotive fringes, and also by the presence and position of a special cavity for the tentacles.

In Pleurobrachia proper, the vertical rows of muscular fibres are eight in number, alternating with the rows of locomotive fringes, beginning about the same height as those on the mouth side of the body, as is seen in Fig. 1, 2, 3, and 5, and extending to about the same distance from the opposite centre, where their arrangement, however, is considerably modified by the peculiar form of the circumscribed area of the anal end of the body. Six of these vertical bundles are nearly identical in their arrangement, but the two lateral bundles (Fig. 2), which extend in the direction of the axis of the tentacles, are somewhat modified by the opening from which the tentacles are issued, their fibres diverging and converging again, so as to have a direct influence upon the cavity in which the tentacles are contained.

Besides these main bundles of vertical fibres, we have as many more bundles alternating with them, which arise from the upper end of the vertical rows of locomotive fringes, and converge towards the margin of the mouth, combining their fibres more or less with those of the alternating bundles, and forming in their combination the powerful contractile apparatus which opens the mouth, and which, when this is shut, appears like a regular area of fibres radiating in all directions, as seen in Fig. 5 and 11, in which the mouth is absolutely shut, and contrasting most remarkably with that opening when spread to the utmost, as in Fig. 10. Similar fibres, though less regularly star-shaped, converge also from the lower extremity of the vertical rows of locomotive fringes towards the anal area (Fig. 4), but, from the peculiar form of the latter, and the curve of the chymiferous tubes around it, they have a somewhat peculiar arrangement.

The circular or parallel fibres or bundles of muscles (Fig. 1, 2, and 4) extend transversely from one row of the locomotive fringes to the other; and although transverse fibres pass under these rows, the circular muscular bundles cannot strictly be said to extend in unbroken continuity all round the sphere, in parallel, horizontal circles; for the chief bundles extend only from one row of vertical fringes to the next, their fibres being chiefly connected with the substance which gives attachment to the locomotive combs, and the number of fibres stretching across beneath being considerably reduced by the great development of the chymiferous tubes which follow the locomotive rows. Again, there are along these tubes, and under the locomotive combs, vertical fibres also, which interrupt the regular course of the circular ones, though the vertical fibres are here less powerful and less numerous than in the middle of the space between two locomotive rows, where the chief vertical bundles are accumulated. Towards the upper or mouth end of the body, however, above the vertical rows of locomotive fringes, the circular fibres seem to be circular all round the mouth (Fig. 10); or at least to form bundles which are crossed by the upper radiating muscular fibres, and interwoven with them, but not broken up into distinct segments of circular bundles. On the anal extremity of the body, the circular fibres are considerably reduced, though there are still some to be seen.

Considered isolately, the muscular bundles cannot be compared to muscles, as they exist in higher animals. They are, strictly speaking, isolated muscular fibres, loosely scattered, but more or less crowded together throughout the gelatinous mass, or upon some particular points of the body, and in particular directions presenting, when contracted, so much of a cellular appearance, as to be easily compared with elongated fusiform cells, assuming, indeed, frequently that appearance, and then passing again into a thread-like form, sometimes regularly swollen in the centre, at other times more to-

wards one or the other extremity, and assuming, therefore, alternately a clavate, or fusiform, or filiform appearance, very much elongated, but nevertheless sufficiently characteristic to be compared to cells, their nucleus being often still distinguishable, but presenting no appearance whatever of striæ across the fibre. From their appearance, and from the change of their form during contraction, I can hardly doubt that they are hollow, and contain fluid. The chief difference in the arrangement of these fibres in Beroid and Discoid Medusæ consists in the circumstance, that in the former the muscular fibres seem to pervade the whole substance of the gelatinous matter which constitutes the main mass of the body; and, indeed, it seems to me that this gelatinous mass is, in its elementary structure, identical with the contractile tissue which pervades it, with only this difference, that the cells which contain the jelly are less contractile, and their liquid contents more consistent. But that even these parts are not altogether deprived of the power of contraction and dilatation would seem to be conclusively shown by the circumstance of the whole sphere in the same individual appearing at times larger than at others. And if this is so, we have here a body made up, to a very great extent, of the same elements as the foot of a mollusk, for instance, but differing in so far as that there the cells are metamorphosed into more perfect muscular fibres, while here the elements of the cells preserve more of the primitive character of such structures, though they undergo also a peculiar modification, inasmuch as we have here an elastic jelly interspread with contractile fibres.

I have been unable to distinguish in Pleurobrachia a special superficial system of vertical fibres distinct from those within; nor are the circular fibres so exclusively internal as in Discoid Medusæ, but interwoven with vertical fibres throughout the thickness of the walls of the body, though the vertical fibres are generally more numerous in the outer part of the main mass, and the circular fibres towards the inner part; as may be seen when examining the mouth in its contracted condition, when the radiating fibres alone are visible externally, as in Fig. 5 and 11, while the circular fibres are chiefly shown when the mouth is fully extended, as in Fig. 10. Though the contractile fibres maintain throughout the body chiefly these two directions, it were an exaggeration to imagine that the fibres all run strictly in either one or the other of these directions. On the contrary, in each bundle or row of either vertical or circular fibres, we find that their course diverges more or less from the prevailing direction, and that, for instance, towards the upper and lower summit of the body, about the height at which the vertical rows of locomotive fringes terminate on the two sides, the chief vertical bundles of muscular fibres diverge to form somewhat pennate bundles of fibres, as in Fig. 4 and 5, and that along the sides of the vertical rows of locomotive fringes the

fibres also show a more or less pennate arrangement (Fig. 1 and 2). But the most particular disposition is in the two lateral bundles (Fig. 2 and 4), which above, towards the mouth, are at first similar to the other vertical bundles, but about the middle of their course diverge to inclose the bases of the tentacles, and form a sort of sphincter to enlarge and shut, in their relaxation and contraction, the opening of the cavity in which the tentacles are contained (Fig. 2, 3, and 4), *b* being a profile view of those bundles of fibres, *e* representing their termination upwards, and *d* their arrangement, when the aperture through which the tentacles issue is fully shut. The peculiar muscles which move the partition of the cavity of the tentacles will best be described with that system.

It has already been mentioned, that there is a wide cavity in the centre of the body of this animal, into which hangs the digestive cavity proper; but the natural relations of these parts are so difficult to appreciate, the ramifications of the cavities so complicated, and nevertheless so regular, and, again, so movable in their constant contractions and dilatations, that, with all the assistance of numerous drawings, as given in Plates III. and IV., I hardly expect to be able to give a correct idea of this apparatus, unless the reader is willing to consider attentively every point of the following description by itself, and to keep, at the same time, constantly in mind the relative connection of all parts, and their bearing upon the general disposition of the body.

In the first place, let it be remembered, and well understood, that the main cavity undergoes constant changes, as to its size and outlines, according to its temporary state of contraction and dilatation, and that both halves of the system of tubes, which arise from the main cavity and branch into the right and left halves of the body, alternate constantly in their contractions; so much so, that the one may be in the state of fullest expansion (Plate III. Fig. 2, *a*) when the other is in the most complete state of contraction; and, after a while, the reverse will take place, when *b* will be fully expanded, and *a* fully contracted. But in these alternate movements, there is a moment when both halves are in a state of apparent equilibrium, though one be in the process of emptying, and the other in the process of filling; but at the moment an equal amount of liquid has been pressed from that half which is contracting into that half which is filling, the symmetry is most complete. These alternate contractions are nearly as regular as the movements of diastole and systole of the heart, and take place by a constant balancing of the fluid alternately one way and the other. The difficulty of watching this singular circulation arises chiefly from the necessity of keeping the living animal in one and the same position in order fully to appreciate these movements, as the slightest obliquity will interfere with the perspective in such a manner as to make it altogether

impossible to follow the natural movements. Again, unless the parts are placed in such a strictly identical position, those which are in pairs will create confusion, as they may come into various positions presenting apparently a close connection with parts to which they are not all related. Again, the peripheric tubes extending vertically over the whole surface cover so easily the origin of the different trunks arising from the main cavity, that it is indeed very perplexing to trace them all in their true connection. Add to these difficulties the circumstance, that the arrangement of parts, owing to the bilateral symmetry of the body, appears entirely different when viewed from the side, in profile, and in front, and it will be plain that, unless one keeps in mind two distinct images of the various connections of all these stems and their ramifications, in a front view and in a lateral view, combining them in thought with the rapidity with which such an animal may revolve upon itself, it will be impossible for him to trace for a moment its structure while alive, and he will only have constantly before his eyes the tantalizing image of a piece of machinery apparently very complicated, the structure of which he has to decipher while it is moving, but moving almost too fast to allow him to seize the connection of the different parts as they pass along, and which is not only deranged, but destroyed, the moment it is stopped. It was under such circumstances that I undertook to study the circulation of these animals, and though I succeeded in injecting indigo into their main cavity, and in having it circulate for hours at a time within the body of the same animal before it died, and though I was satisfied that not a particle of the colored liquid had passed into any part of the body into which the liquid before it was colored had not naturally free access, and though it was thus plain to me, that, even after being colored, the circulating fluid continued its normal course, I must say that I never investigated a more difficult subject, never had to devote so much time to the same point, and never taxed my patience to such an extent, as during these investigations. I insist upon these details, and state them at full length, because I know that I have now cleared up this subject, and may perhaps induce some other student to go through the long description I am about to give of it, since he can expect to have the matter settled for him. Let us proceed in this description as we should with a minute description of the ramifications of the blood-vessels of some highly organized animal. The difference which exists between the digestive cavity and the main cavity of the body will first engage our attention.

In a front view (Plate III. Fig. 2), when the two tentacles appear right and left, and the plane which passes through the longitudinal fissure of the mouth divides the body into halves, we have before us, on our right, one of those halves of the body, which alternates in its contractions with the other half on the left. It is according to this

diameter that the antagonism between the two sides is introduced. Seen in this view, the digestive cavity appears throughout like a narrow fissure, *c* ; but as it is wider in another direction, its outline, as seen in Fig. 1, is very broad. The fact is, that this cavity is a flattened sac, flat as long as it is not full of food, and the two surfaces of the flattened bag are pressed upon each other ; so that when seen in profile, that is to say, facing the longitudinal diameter of the body, as in Fig. 2, it appears like a mere double skin, or a slit lined with a membrane ; but when seen from its broadside, that is to say, facing the right or left side of the body, as in Fig. 1, it appears like a wide sac, and only during the process of digestion is it swollen into a more rounded sac or cylinder. The lower extremity of this sac is projected into the main cavity of the body, terminating there in a large opening, which, at the will of the animal, can be shut or opened ; so that, like the stomach of Actinia, the central digestive cavity of Pleurobrachia communicates with the cavity below, or is shut up by itself. The difference between the two genera, however, consists in the limitation of the cavity of the body, which, as such, is circumscribed within the centre of the animal in Pleurobrachia, and sends off large trunks and tubes, branching diversely into its mass and along its surface, while in Actinia the whole body is hollow, and the stomach empties into that one large cavity.

The central cavity has two main stems, one extending into the right, and the other into the left half of the animal, as is seen in Plate III. Fig. 2, 3, and 4. It would seem from Fig. 2 as if the largest sac were hanging loosely in the central cavity ; this is not the case, however, for the spaces communicating with the main cavity right and left of the digestive sac in this figure do not form a continuous cavity encircling the whole digestive sac, but are only two tubes, which arise from the main trunks of the central cavity, and follow the middle of the lateral surface of the compressed digestive sac, in an ascending course, up to the margin of the mouth, being simple narrow tubes, as Fig. 1 shows. Downwards, however, the main cavity extends in the form of a funnel, terminating with two holes near the centre of the area below. This funnel descends in the centre of the animal vertically, and lies, therefore, in its central axis. It assumes nearly the same appearance in whatever position it is seen, excepting, however, its termination below, which is furcate when seen from the side, as in Fig. 1, and simple when seen in front, as in Fig. 2. This part of the cavity and the main lateral trunks being, as it were, the centre of the circulation, we may view it as an axis which branches right and left, and which rises in the centre in two parallel forks up to the mouth ; so that, when seen from the side, the double upper fork is seen as one, but the lower fork, which is at right angles with the former, is distinctly seen, and *vice versâ ;* the main lateral stems and their ramifications present in the first position their broadside, and appear foreshortened in the other.

The two main lateral trunks (Fig. 2, *a*, *b*) branch off at right angles from the central cavity, and extend horizontally for some distance sideways, ascending slightly, changing their position, however, to some extent, according to the state of contraction or distention of the digestive cavity. Five branches arise on each side from these main trunks, or rather three, as we may view them. Perhaps some observers would say four, and really it is difficult not to exaggerate their connection, or to distinguish sufficiently between their branches. The fact is, that, before branching again, the two main trunks form, at their extremity, sideways, a sort of dilatation, from which arise two lateral branches extending horizontally backwards and forwards, and two close together, which may therefore be taken for one, ascend in a vertical direction upwards. Thus the main branches from the first trunks are either three or four, as we consider the vertical one as two parallel stems or only as one; but as the branches extending horizontally forwards and backwards give out not far from their origin two others, which extend also horizontally sideways, nearly at right angles with the former, and as all these branches originate so near the point where they communicate with the primitive main trunks, they may all with almost equal propriety be considered as arising directly from it. And if this view be taken, the main trunk may be said to have five branches, four horizontal ones, and one with two parallel tubes ascending vertically. The fact is, that the termination of the main trunk may contract or dilate in such a manner as to present alternately these different aspects. For instance, in its most contracted state, when seen from above, as in Fig. 3, there are distinctly six branches arising from the main horizontal trunk, the two vertical ones appearing like very short tubes, though they are actually as long as the others, because their whole length is foreshortened upon their origin, while the four horizontal branches are seen for their whole extent, two and two, however, united by their base; so that it may with equal propriety be said, that on the whole there are only four tubes, the two horizontal ones branching soon again into two: or, in the dilated state of the main trunk, when the branches arising from it are in a state of contraction, they all seem to originate from one common cavity, as represented in Fig. 4. Here the four horizontal tubes really seem to arise independently of each other, and the two vertical ones are brought so close together as to appear like one, making altogether five branches. In another state of contraction, the two vertical ones may seem united, and the two pairs of horizontal ones also, when there appear to be only three branches to the main trunk; and, unless the dilatations and contractions of these curious ramifications of the stems have been watched for a long time, these differences may remain unnoticed, but when fully understood, there is no contradiction in the apparently conflicting statements that there seem at times to be three, at times four, at

times five, and at times even six branches to the main trunk. I should add, that, when seen from above or from below, unless the body is somewhat inclined, the vertical tubes altogether escape attention, and that the best position to ascertain their relative connection is a somewhat oblique external side view, as in Fig. 5. In Fig. 1, which represents the whole system in the same position, the view of the horizontal main trunk and its branches is somewhat confused, from the circumstance that it is projected upon the vertical central cavity, and the prolongation of that cavity upwards and downwards; but in Fig. 5 we have only the peripheric branches arising from the main trunk, that is to say, the portion seen to the right of Fig. 2, 3, and 4; while in Fig. 1 we have, besides that half, the central axis also, as likewise in Fig. 2.

I have described these peripheric branches as horizontal, and so they appear when seen from above or from below; but in a vertical position they are seen to be somewhat deviating from the same horizontal plane, the main branch reaching the periphery somewhat higher than the secondary branch, and the vertical branches inclining slightly outwards. These different branches have by no means the same functions, and are not connected with the same apparatus, the vertical branches extending into the peduncle or cavity from which the tentacles are protruded, while the horizontal branches communicate with vertical tubes, which follow the inner surface of the vertical rows of locomotive fringes for their whole extent.

As there are on each side four such horizontal branches and four vertical rows of fringed combs, there are also, in the whole, eight vertical superficial, chymiferous tubes, widest in the middle, and tapering upwards and downwards, which are in most strict communication with the central cavity through the four horizontal tubes, and the two main trunks, from which they themselves arise. The upper ends of the superficial vertical tubes, which I may call the ambulacral tubes, terminate apparently in a blind point; at least, I have been unable to trace a direct communication between any of them and the vertical tubes which follow the sides of the digestive cavity, though such a communication is seen in the genus Bolina, as I shall mention hereafter; it may, therefore, have escaped my attention in this genus. But whether there be such communication or not, the fluid circulated upwards through these tubes can be distinctly seen to retrace its way downwards; so that, in the ascending branch of the ambulacral tubes, the fluid injected through its horizontal branch is moved up and down alternately. This is also the case with the lower branch of the same vertical tubes, though the lower end tapers gradually into very slender tubes, which extend as far as the anal area, and unite there again with the central cavity. But this termination of the central tubes being too narrow to allow all the liquid injected into the larger stem to pass through, the

liquid moves here also up and down. The movement, in reality, takes place in the following manner. Each of the eight horizontal tubes fills its vertical ambulacral branches, the fluid flowing, at the junction of the horizontal tube with the vertical stem, in two opposite directions, upwards and downwards. A small quantity passes through the narrow prolongation of the tubes below back into the main cavity; but the greater portion flows back during the contraction of the mass which has been moved upwards, is pressed into the horizontal tube, and returns to the centre of the movement to pass into the opposite side of the body. It may be, also, as mentioned above, that a small portion of the fluid passes through exceedingly minute tubes into the vertical tube of the stomach, and back into the central cavity, in the same manner as upon the anal extremity, as this is really the case in Bolina. However, this communication above and below is too narrow to establish a direct onward circulation; the liquid moves decidedly to and fro in the ambulacral tubes, and returns chiefly to the central cavity through the horizontal tube, and, what is still more interesting, the dilatation of the four tubes of one side alternates with the dilatation of the four tubes of the opposite side. Moreover, in each vertical ambulacral tube, the motion of the fluid is an undulatory one, owing to the alternate dilatation and contraction of the tube itself, as shown in Plate II. Fig. 6. The movement of the fluid in these tubes can be traced very satisfactorily, when following the course of the minute granules of colored matter suspended in the water after injection; but even in fresh specimens uninjected, the circulation can be tolerably well traced by watching the small particles of undigested food suspended in the mixture of water and chyme which is circulated throughout this system. As in Polypi, the whole mass of digested food, comminuted and reduced to a very uniform state, but in which the parts capable of being assimilated are still mixed with the refuse matter, is indiscriminately emptied into the main cavity of the body, and, with a certain quanity of water introduced in the same way into this cavity through the mouth, kept in a constant regular undulatory circulation throughout life. But as there is a double outlet through which this system can discharge its contents on the side of the anal area, the circulation is more or less active, all the tubes more or less turgescent, and the whole cavity more or less dilated, as the quantity of fluid in circulation is greater or less, which, to some degree, changes the relative position of the tubes and the central cavity. When very full, the wider central space is considerably raised, while in a state of relaxation it sinks lower down, nearer the anal extremity of the body. As long as the circulatory system is relaxed, the ambulacral tubes are very much contracted, their diameter is much less than under other circumstances, and by no means equals the width of the vertical rows of locomotive fringes; but when turgescent and full, they swell beyond their width. The

force which acts in propelling the liquid through the system is not the same throughout. The alternate contractions of the two sides result from the muscular contractions of the two sides of the body regularly alternating; but the main cavity in its central parts is entirely lined with vibratory cilia, so that even when the body is perfectly at rest the fluid is maintained in a constant rotatory motion through their agency. I have repeatedly and distinctly seen these cilia playing round the lower opening of the digestive cavity, and upon the walls of the vertical, central, circulatory cavity, as well as upon the walls of the main horizontal stems, and upon the walls of the inferior vertical funnel, even as far as its two forks which diverge below. I have been unable, however, to discover similar cilia within the secondary horizontal tubes, or the vertical ambulacral tubes. I have also failed to discover them in the vertical tubes of the tentacular cavity, though they may exist there also. However, the contractions of this latter cavity by muscular power are so extensive, that the agency of vibratory cilia does not seem to be required to keep the fluid in motion in that part of the system. I should nevertheless add, that even the walls of the central cavity, where they are most distinctly lined with vibratory cilia, are also fibrous, and that these fibres are distinctly contractile, and the capacity of the cavity is not only increased and reduced in a passive manner by the accumulation of fluid or its expulsion, but also actively by the contraction and dilatation of the walls themselves. How the contents of this circular system are diffused into the substance of the body for nourishment is not very plain, as there are no capillaries, but everywhere broad tubes. From the structure of the whole mass, however, we may infer that assimilation takes place by a process of endosmosis and exosmosis. If this view is correct, we should consider the two ascending tubes upon the middle walls of the digestive cavity as the nourishing vessels of the stomach; the two main horizontal trunks as two respiratory vessels, branching into eight branchial vessels, which are the main trunks of the eight ambulacral vessels; and the vertical funnel below as a vascular cloaca, discharging its contents through two distinct apertures on the sides of the anal area near the lower centre.

The vertical tubes ascending into the sacs from which the tentacles issue seem to have a peculiar function, and to be directly connected with the movements of the tentacles, and these movements, again, to be connected with the alternate contraction of the two halves of the body, as there are no parts which undergo so extensive changes in their size, and in their state of contraction and dilatation, as these sacs. But their structure is so complicated as to require a minute description.

The two tentacles (Plate IV.), with their elongated cavity and the vertical tubes, which penetrate into the base of the sacs, constitute, indeed, most complicated pieces of

machinery, in which hydrostatic power, elastic levers, and muscular action give rise to highly complicated combinations and most diversified phenomena.

In the first place, the cavity itself from which each of the two tentacles issues (Plate IV. Fig. 1, 2, and 5) is a wide, elongated, pear-shaped sac, the rounded extremity of which is turned upwards and bent obliquely outwards, so that its convexity is turned towards the centre, and its blind sac upwards and outwards, and its open lower extremity downwards and outwards. In this cavity, to which the surrounding water has free access through the lower opening, the tentacle, with its complicated base, is attached by a broader surface to the inner side of its upper part. And though the central cavity of the body communicates freely, through the vertical tubes of the main horizontal trunk, with the base and curved hook of the tentacular apparatus, there is no free passage from one of the cavities into the other. The fluid which is injected into the vertical tubes runs back through the same channels into the main trunk, and the water which washes the central cavity of the tentacular apparatus empties through the same lower opening by which it is introduced. In a state of dilatation water penetrates from without into the pear-shaped sac, and chyle is injected from within into the vertical tubes; and in a state of contraction the chymiferous tubes are emptied at the same time that the water is pressed out. (Plate IV. Fig. 1, 2, and 5.) During these alternate contractions and dilatations, the tentacle itself may be coiled up in the cavity, or drawn out at full length, though in the most dilated state the threads generally hang out. But there seems to be also an antagonism, in a middle state of dilatation, between the filling of the vertical chymiferous tubes and the protrusion of the tentacle, the motions of which depend partly upon the muscular action of the apparatus to which it is attached, and partly upon the state of dilatation of the tubes on the inner surface of its base. The dilatation and contraction of the tentacular cavities depend upon the contraction and dilatation of the vertical bundles of muscular fibres of the two lateral zones, and more especially of the sphincters around their lower extremities; the sphincter reducing the diameter of the cavity, and shutting its opening, while the vertical bundle shortens and widens the whole cavity.

To form a correct idea of the ever-changing state of these parts, it is necessary to keep in mind their form and structure, as well as their relative position. The base from which the tentacle arises (Plate IV. Fig. 5) is an oblong disk encircled by elastic springs around its sides, which are bent inwards at its upper end, and turned outwards and downwards in the form of a hook projecting outside. The flat base of this disk forms the inner partition of the cavity in its upper part, and the vertical chymiferous tubes, which penetrate into the base of the tentacular apparatus, rise close together

and parallel to each other, at its lower margin diverging somewhat to reach the summit of the disk, but keeping nearly parallel between the marginal spring and its medial arch. From the summit the tubes also bend outwards and downwards, and terminate in blind sacs below the middle of the flat disk, so that, seen in profile, as in Plate III. Fig. 2, and Plate IV. Fig. 2, they appear like a tube terminating in a blind sac in the shape of a hook; but seen from the side of the animal, or by the broad surface of the disk, the curved termination of the tubes covers the upper portion of their ascending branches, as is seen in Fig. 5 of Plate III.

The action of the filling of this tube is, therefore, to project the whole apparatus into the tentacular cavity, and to stretch its upper hook outwards; the impulse to a retrograde movement of the fluid is probably derived from the elasticity of the spring encircling the flat disk, and especially from the pressure of its curved middle branch, aided perhaps by the action of a minute muscle, which descends obliquely from its lower extremity, and is attached to the inner wall. The figures of Plate IV. represent this apparatus seen in various positions, in order to make all its details as clear as possible; and in order fully to appreciate them, its position in the main cavity of the body should be contrasted with other figures illustrating the general arrangement of the circulatory tubes, as seen in Plate III., and especially the vertical tubes (Fig. 2 and 5) rising into the tentacular cavity. The base of this apparatus, being attached by its flat side to the inner wall of the cavity, appears in profile, in a front view of the animal, so that the flat disk is represented by a narrow margin, as in Fig. 2 of Plate IV., when its whole height is apparent. Seen from the sides of the animal, its width becomes distinct, and the elastic springs encircling its margin, and rising from the upper summit along the middle to form the external hook, are seen in face, as in Fig. 5 of Plate IV. Seen in half profile, or in a three-quarter view, both margins and hook become distinct, as in Fig. 1 of Plate IV.; and the tentacle which arises from the hook can be traced from its origin through the upper part of its course. In these three figures the whole height of the apparatus is equally apparent; but in Fig. 3 and 4 the cavity and apparatus are foreshortened, being seen from above in Fig. 3, and from below in Fig. 4. In Fig. 3 the curves of the springs in the upper margin are plainly visible, and the two tubes ascending along the inner wall appear like two holes. In Fig. 4 the origin of the tentacle is more particularly shown. In order to form a correct idea of the relations of the tentacle proper with the flat disk from which it arises, it is necessary to keep distinctly in view the arrangement of the springs encircling the disk. Whether these springs are a mere swollen margin of a membranous coat, or a fold of the inner wall of the cavity, or an organ of a peculiar tissue, I have not been able to ascertain. However, so much is certain,

that along the vertical chymiferous tubes which arise towards the upper end of the tentacular cavity, there are on each side linear edges slightly swollen in their middle, and thinner below, but curved over the middle of the disk from above, where they unite; then, descending somewhat lower, they are detached from the outer surface of the disk, to meet on their lower margin a similar fold rising from below, and then hang downwards into the bottle-shaped cavity free, as an independent thread, surrounded as soon as it is free from the disk by numerous small elastic and contractile tentacles. The main thread, however, forms the stem of the tentacle, which is capable of an extraordinary development, and can also be contracted into a coiled bundle; so that, in the state of utmost contraction, it forms a sort of irregular ball of tuberculated appearance hanging from the hook, the tubercles of the surface being the lateral fringes; but when elongated, it is changed into a fine thread, and the fringes appear at intervals, either in a contracted or elongated form, assuming, in the former state, the appearance of little tubercles, which in their elongated condition are themselves like so many little threads. In Fig. 1 and 5 of Plate IV., as well as in Fig 5 of Plate III., the tentacle being in its state of elongation, the lateral threads are distant from each other. Their arrangement in this part of the tentacle, however, is not easily ascertained; but when expanded, or regularly contracted within moderate limits, we cannot fail to see that they all arise from one side of the main thread, and are throughout unilateral. The variations which they undergo in their various degrees of contraction and expansion having already been described, when speaking of the movements of these animals, I need not refer to the subject again. I shall only mention that they appear frequently coiled up like a corkscrew in a regular and more or less elongated spiral. But, strange to say, in this position, though placed upon the two sides of the body in a symmetrical position, the spiral is not antitropic, but coiled in the same direction on both sides of the body, though their bases and hooks, and, indeed, the whole upper part of their structure, show a regular antitropic arrangement, like all symmetrical parts throughout the animal kingdom. Here, however, I have constantly found the spirals of the threads, when coiled up, curved in the same direction, both of them turning to the left in an ascending direction, or to the right in the opposite direction. This is the more surprising, as in animals in which there are parts twisted upon the two sides of the body, those of the right side are curled in one direction, and those of the left side are curled in the opposite direction, thus establishing perfect symmetry; and this law of nature is imitated in architectural ornaments, to produce complete symmetry. Thus, the horns of cattle, sheep, and goats are twisted, the right to the left, and the left to the right, while in antelopes the direction is reversed, the right horn being twisted to

the right, and the left horn to the left. The same is also the case with the bend of tusks in elephants and wild-boars, of the horns in deer, &c. Such an antagonism seems, therefore, not yet to prevail among Radiata, in which the anterior and posterior extremities have not become prominent.

Plate V. gives some further details of the structure of these tentacles. The main thread, a portion of which is represented in Fig. 1, consists of elongated muscular fibres, among which the nuclei of their primitive cells are sometimes still preserved, as seen in Fig. 8. The surface of the thread is covered by several layers of epithelial cells, among which, however, I have noticed no great differences in form and size, and I have also failed to discover lasso-cells among them, though these tentacles are endowed with an intense power of nettling, as they strike dead almost instantly any small Entomostraca which come within their reach.

As shown in Fig. 1, the lateral fringes arise uniformly from the same side, and where one is occasionally seen in a different position, it is easily ascertained that it is out of shape, owing to pressure when placed under the microscope. These lateral fringes have the same structure as the main thread, consisting of a bundle of elongated fibres in the middle surrounded by epithelial cells. The longitudinal fibres, however, extend into the main thread, where they appear like transverse fibres. There seem, however, to be no transverse fibres proper to any of the lateral fringes, nor even to the main thread, as, in every instance, I could trace those transverse fibres of the main thread into the centre of the lateral ones. The extension of the threads must, therefore, be of a more passive character, owing to the relaxation of the fibres, rather than produced by the contraction of annular fibres. The longitudinal fibres of the lateral fringes, however, may probably contribute in their contraction to the elongation of the main thread. This disposition explains very fully the slow elongation of the tentacles, in comparison with their quick and almost instantaneous contractions, and also the peculiar phenomenon attending this elongation, when, by starts, the main thread seems rather to be dropped from point to point to its fullest elongation, in a passive way, by the relaxation of the fibres. I am, however, at a loss to explain by their structure the elongation of the lateral threads at right angles with the main thread, when this is fully expanded, and their various dispositions, their frequent straight and apparently stiff elongation, and, still more, their sudden bending even in acute angles. These motions are so diversified, and sometimes so sudden, as to astonish even those familiar with the movements of these animals.

Having described above the position and changes of form of the digestive cavity, I have now only to add, that its inner surface has not throughout the same appearance, and is

not uniformly flat. Near the aperture of the mouth, indeed, it is smooth, and when the mouth is fully expanded a broad funnel is opened leading directly into the digestive cavity, assuming, however, in its contractions very diversified forms, being at times perfectly circular, and at other times oblong, oval, or even angular. The anterior and posterior angles of the mouth form frequently a fold, as in Fig. 5 of Plate IV. or in Fig. 2 of Plate II., and in Fig. 3, 4, 5, and 6 of Plate V.; or it assumes a linear shape, as in Fig. 7 of the same plate, or a stellate form, as in Fig. 5 and 11, Plate II. The more the mouth is open and spread out, the more easy it is to follow to a considerable depth the tubes which rise vertically along the walls of the stomach, as seen in Fig. 3 of Plate III., where they are slightly bent sideways to show their origin from the main transverse trunk below. The walls of the stomach lower down present four folds, two of which are in the direction of the fissure of the mouth, along the anterior and posterior walls of the stomach, and two others at right angles with them along the middle of its broader wall, in the plane of the transverse axis of the body. These four folds are lined with brown cells, and constitute probably a rudimentary liver, or at least secreting cells aiding in the process of digestion. Towards the lower extremity of the digestive sac, between those prominent folds, the walls of the digestive cavity are lined with a vibrating epithelium, which is particularly active round the lower opening of the sac, when this is fully open. This vibrating epithelium is continued upon the outer surface of the sac, and lines also, as already mentioned, the inner central cavity into which the stomach thus projects. (Plate III. Fig. 6 and 7.)

If we now view this animal from the opposite side, we find a variety of organs, the structure of which is not easily understood. Considering them at first chiefly in their forms, it will be seen that there is an elongated area, well circumscribed in its outlines, extending in a longitudinal direction in the same plane as the mouth, with a black speck in its centre (Fig. 4 of Plates II., III., and IV.). Towards the centre of this area eight narrow tubes are seen diverging (Fig. 4 of Plates III. and IV.), and in an oblique position two indistinct projections may be observed near the margin of the area. What all these parts are is not easily ascertained, and it is still more difficult to determine their connection with other organs. The black speck in the centre (Plate V. Fig. 9 and 10) rests upon a tubercle within, which is itself encircled by a tube; but the narrow longitudinal area is a membrane with a well-circumscribed and somewhat prominent margin, covering a hollow space. The irregular transverse bulbs at the base of its anterior and posterior halves, near the black speck, are the swollen extremities of two branches of the medial vertical funnel. And if we start from these facts, we may perhaps throw some

light upon the structure and functions of the whole apparatus. Let us, for this purpose, go back to a renewed consideration of the funnel itself. We have seen that it is simply a central, vertical, downward prolongation of the main central cavity, tapering gradually into a narrow neck (Plate III. Fig. 1 and 2); but before it reaches the lower surface, it enlarges again very suddenly, branching into two forks, which are themselves swollen into two irregular bulbs resting against the lower surface, one in front, and the other behind the central black speck, but both close to it, and partly encircling the tubercle upon which the black speck rests. These two bulbs are therefore simply dilatations of the forked lower extremity of the funnel, and we constantly see undigested matters accumulated in them and revolving in their cavity, with a tendency to accumulate laterally in an obliquely opposite direction in each of them. And at long intervals these prominent oblique angles will open (Plate V. Fig. 9), when the fecal matter within the bulbs is discharged, the aperture remaining for a longer or shorter time extended, and the vibrating cilia lining the inner surface playing very actively; but after a little while, these openings shut again.

These apertures might, therefore, be considered as a double anus; but I think it were a very injudicious comparison to homologize them with the anus of higher animals, for in this type the process of digestion and assimilation, and the circulation of the nutritive digested food, are carried on by means of apparatus widely different from what we observe in either Mollusca, Articulata, or Vertebrata. We have seen above, that the food is introduced into the digestive sac which hangs into the central cavity; that this sac opens freely into that cavity, and discharges there its contents, mixed with a large quantity of water; that this peculiar apparatus is subject to regular contractions, and circulates the fluid, with the nutritive parts suspended in it, into the various tubes branching through the whole system, and that gradually the refuse matters drop into the central vertical funnel, to be discharged below through the openings of the two hollow bulbs branching from its lower extremity. We have here, therefore, rather openings in the circulatory system than anal apertures, or rather, we have here an apparatus entirely different in its adaptation from either the alimentary canal or the circulatory system of higher animals, but constructed upon the same plan as similar apparatus in the class of Polypi and in other Medusæ, with only this difference, that in Polypi the digestive central sac empties its contents into a large cavity subdivided only with partitions, without definite circulatory tubes, but along which the fluids are nevertheless circulated up and down, and into the tentacles, and discharged either in a retrograde current through the stomach and mouth, or through the tentacles and lateral pores, when such exist. In Discoid Medusæ a similar circulation takes place, but without openings either in

the periphery or opposite the mouth; at least not in the Naked-eyed Medusæ, though the fluid discharged from the digestive cavity is circulated through tubes into the periphery and around it, and the refuse matters, retracing their course, are emptied through the mouth. Whether any Medusæ have peripheric openings through which the refuse matters are discharged, as Ehrenberg maintains, I have been unable to ascertain. However this may be, so much is plain, — that, in Medusæ and Polypi, the whole digestive apparatus is in direct broad communication with the circulatory apparatus; that the fluid circulated is simply chyme mixed with water, carried through all parts, which either retraces its course or is discharged through particular openings of the circulatory apparatus; and that there is no continuous alimentary canal with an anterior and posterior opening, and no distinct circulatory system deriving its fluid through lymphatics from the alimentary cavity, but two closely connected systems, one presiding chiefly over the function of digestion, and the other circulating the whole mass of digested food, that is, chyme mixed with water. It will, therefore, be more proper to call the upper sac the digestive sac, the central cavity with its branching tubes the chymiferous sac, and the vessels chymiferous vessels; and to consider the circulation, not as a blood-circulation, but as a chymous circulation, and, in some degree, the centres of this circulation, which act in antagonism to each other by their alternate contractions, as a sort of chymiferous heart.

If we next consider the oblong area and its cavity, I am able to state that the hollow space below, which extends forwards and backwards from the two cloacal bulbs, is a direct prolongation of the cavity of the bulbs, lined equally with vibrating cilia, and in which the fluid accumulated in the bulbs moves also to and fro. (Plate V. Fig. 9.) The ridge which circumscribes the outline of these tubular sacs is very definite, and slightly prominent upon the surface, though smooth. But in some Beroid Medusæ, such as the true Beroe, this ridge is slightly fringed, and it may be that these fringes constitute rudimentary gills, and that the marked outline of the area in our Pleurobrachia is a rudimentary development of such fringes.

The narrow tubes alluded to above, as converging towards the centre of the circumscribed area, can be traced from the lower extremity of the vertical rows of locomotive fringes to the immediate vicinity of the black speck in the centre of the lower end of the body. These tubes are direct prolongations of the vertical or ambulacral chymiferous tubes, tapering gradually towards the lower extremity of the animal, and extending beyond the rows of fringes proper, but reduced in their diameter so much as to appear now as very slender tubes converging from the lower summit of the locomotive fringes to the centre of the lower surface of the animal. These tubes are eight in

number, like the ambulacral tubes of which they are the continuation, and they converge two and two, being more closely brought together in pairs towards the black speck of the centre. (Plate V. Fig. 9.) In their respective position they differ somewhat; though rising from the four lateral ambulacra, they preserve a rather straight course from the summit of the rows of fringes to the centre of the area; the anterior and posterior ones, however, bend towards the elongated part of the area, and follow obliquely the course of its margin, thus contrasting in some degree with the lateral ones. How these tubes terminate I have not been able to ascertain in a direct manner, but am inclined to suppose that they empty into the lower bulbs of the funnel. The tubes are so fine, and the circulation beyond the main stem of the chymiferous system is so easily stopped as soon as the animal is not in the most favorable circumstances, and coarse materials in addition to pure homogeneous liquids are so unlikely to be forced into these narrow channels, as hardly to afford an opportunity to watch the direction of the current. Perhaps a comparison of the different arrangements of these tubes in various genera may lead to a more satisfactory result respecting this point of the circulation.

I am equally at a loss to account for the precise connection between all parts which may be seen around and above the central black speck (Plate V. Fig. 9 and 10). Even the nature of this organ is very problematical. In its appearance it resembles somewhat the marginal colored specks observed in Discoid Medusæ, and on that account has been viewed by some as an eye-speck; but by those who consider the so-called eye-specks of Medusæ as rudimentary auditory organs, it has been considered as an ear-speck. But notwithstanding the difference of opinion upon its functions, all naturalists who have examined Beroid Medusæ have identified the black speck, which occurs in a central position upon the extremity opposite the mouth, with similar specks occurring about the periphery of Discoid Medusæ. But in my opinion this comparison is not correct, and I am inclined to consider this organ or this speck as something similar to the central colored speck which occurs in the middle of the disk in Discoid Medusæ, and which is particularly distinct in young animals soon after they have been detached from the polyp-like stem upon which they grew, — as a remnant of the connection which exists between the mother stem and its progeny in those Medusæ which multiply by alternate generations. This homology cannot for the present be sustained by direct observation, since the embryology of Beroe is as yet entirely unknown. But I should not be at all surprised, if Beroe were found to be the free Medusa form of some Hydroid Polyp from which Medusa-buds have not yet been observed; for the analogy between this central speck and what might be called the remnant of an umbilical cord in Discoid Medusæ is far greater than may at first sight be supposed. Its position in the centre of the summit

of the chymiferous cavity is identical with the position of a similar peduncle observed most easily in young Sarsiæ soon after their separation from their Corynoid stem. The circumstance, that at this extremity the chymiferous cavity has two openings in Beroid Medusæ, does not institute between them and the common Discoid type a greater difference than exists between the star-fishes with a central anus and those which are deprived of this aperture, and cannot on that account be considered as establishing a radical difference between the structure and arrangement of the main systems of the body in the two families. On the contrary, the circumstance, that here eight tubes, probably in connection with the central cavity, diverge towards the periphery, to extend vertically along its walls, and gradually to enlarge along the sides, establishes a close resemblance between the ambulacral tubes of Beroe and the vertical chymiferous tubes of the naked-eyed Discophoræ. Again, the circumstance of their uniting to form a circular tube around the periphery may be compared to the circumstance of the ambulacral tubes meeting in the peripheric horizontal tubes arising from the main central chymiferous cavity. There are differences in the number of parts, and slight differences in the manner in which they are carried out in their adaptation; but, on the whole, the relations between the mouth and digestive cavity proper, the central embryonic tubercle, and the chymiferous tubes, are essentially the same in the Beroid Medusæ and the Discophoræ.

There are some further complications in the Beroid, which are not yet carried out in the Discoid Medusæ. We shall see that Bolina in this respect is even still more complicated than Pleurobrachia. But this no more changes the fundamental relations, than the complicated ramifications of Astrophyton change the relations of that genus to Ophiura. They are essentially the same. Above the black eye-speck in the natural position of Pleurobrachia, or below it in those Beroid Medusæ in which the anal extremity of the animal is turned upwards, as in Bolina, there is a tubercle or ganglion-like mass of larger size than the black speck itself, consisting of heterogeneous elements, which seems to be encircled by a tube some way or other connected with the eight narrow converging ambulacral tubes, on the anterior and posterior side of which are seen four smaller tubercles or swellings, between which arise two threads rapidly diverging forward and backward, and extending into the circumscribed area. I can offer only suggestions respecting these parts, and must leave it for future investigations to decide what they are in reality. I am, however, inclined to suppose that the circle at the base of the ganglion is a vascular or chymiferous ring, answering to the ring observed above the proboscis in Sarsia, and I expect it will be proved that the eight narrow tubes connected with the ambulacral tubes arise from this circle, or empty into it. The four swellings in advance of and behind the tubercle

are probably vascular dilatations of this ring, similar, in respect to the position where they occur, to the bulbs of the funnel and the two threads between them extending forwards and backwards are probably only outlines of the folds which form the circumscribed area. But there is no part of the structure of Pleurobrachia upon which I can be less positive than upon this point.

As for nerves which are said to arise from the ganglion connected with this black speck, I have been unable to make them out. I have seen numerous muscular or contractile fibres connected with the lower extremity of the chymiferous funnel; I have seen these fibres diverging from above the so-called ganglion, but have never been able to trace any one of them beyond the length which contractile fibres have: again, I have repeatedly seen these fibres in a state of contraction or relaxation, presenting so little regularity in their distribution, that for the present I think it were rather assuming to decide upon the disposition of the nervous system of Beroid Medusæ. I am even satisfied, from the descriptions published, that the eight converging narrow tubes, of which I find no mention in former authors, must have been probably mistaken for nervous threads by some; and when Professor Grant states that Beroe has eight nervous threads arising from a central ganglion, I suppose he alludes to the central black speck and its swollen base, and the eight narrow chymiferous tubes, the connection of which with the ambulacral tubes is so easily traced, though their central connection with the vertical funnel still remains doubtful. I do not, however, deny that this centre is a point where we have to look for at least one part of the nervous system, and the gelatinous lobes about the mouth for the other part, if there be really a distinct nervous system in Beroid, as in Discoid Medusæ. But, for my own part, I have failed in tracing it out; though I may add, that I am sufficiently acquainted with the structure of the region where it is said to have been observed, to doubt the accuracy of the statements which have been made about it, especially in the precision and distinctness with which it is mentioned. And I express these doubts, notwithstanding the doubts I have myself respecting the real nature of some organs around the central black speck, for the very reason that, after finding there more than has been seen and described, and various things which may answer the vague descriptions given, I do not in reality find what has been said to exist in that part of the animal. The points to which future investigations should be directed with particular care are especially the relation which the central black speck may have with the formation of Beroe as buds from Hydroid Polypi; next, the connection of the eight narrow tubes with the central funnel; and finally, a more thorough investigation of the tissues above the black speck and within the circumscribed area, and the apparent termination of the narrow tubes.

Although I have kept Beroe alive for a month during spring, I have never seen in any of them any thing like ovaries and spermaries, and have not even succeeded in ascertaining in what part of the body the organs of reproduction are developed. And I must confess that the descriptions published by various authors respecting the sexual apparatus of Beroe have not yet satisfied me of the correctness of their statements.

BOLINA.

The genus Bolina was established in 1833 by Mertens, from two species, one of which was observed in the Pacific, and the other in Behring's Straits. The genus is characterized in a remarkable paper on Beroid Medusæ, published in the Transactions of the Imperial Academy of Sciences, in St. Petersburg, in the second volume of the sixth series. It is considered as distinguished from other genera of that family by the great development of the mantle lobes, and by the circumstance of its eight rows of locomotive fringes not extending beyond the body itself; and though this characteristic is not strictly correct, in as far as I shall be able to show that the ambulacral rows are not strictly circumscribed within their apparent limits, the genus itself is a very natural group, which ought to be generally acknowledged. It is difficult to give a correct idea even of the forms of these animals, as they assume constantly different aspects in their various movements, and in the different attitudes in which they must be considered. Having had an opportunity to examine at repeated intervals, and for a longer time, a new species of that genus, which I have kept alive for months, I shall attempt to give a more complete idea of its remarkable structure, which may throw some new light upon the organization of the whole family, and also upon the natural relations which exist between its different genera. I saw this new animal for the first time, with Mrs. Arnold, of New Bedford, who had preserved it alive for my examination, in December, 1848. I myself afterwards found large numbers of specimens, during the months of March and April, and even as late as June, in various parts of Boston Bay. Dr. A. A. Gould, however, had already noticed this species as an inhabitant of the shores of Massachusetts, in his Report on the Invertebrated Animals of that State, where he considers it, however, as identical with the Alcinoe vermicularis of Europe. But a close examination has satisfied me that it is neither identical with that species, nor even belongs to the genus Alcinoe, but constitutes the first Atlantic representative of the genus Bolina.*

* It is a remarkable circumstance, that the Atlantic shores of America should furnish, in lower latitudes, a species of that genus so similar to that which occurs in Behring's Straits; but this is only one of the

There is a very marked difference between this species and Bolina elegans of Mertens, in the form of its lateral auricles and in its color, which is not rosy, as in the species from the Pacific, but of a milky bluish-white, as in Bolina septentrionalis, with which it agrees in the form of its auricles, differing from it, however, in the less limited development of its longitudinal diameter, in the greater approximation of the two auricles of each side, and in the greater width of the mantle lobes, for which reason I have called this species Bolina alata.

It is a most delicate, transparent, and diffluent animal; so soft, that it readily decomposes under the least unfavorable circumstances. The admixture of a small proportion of fresh water in the bowls in which I used to preserve them caused not only their immediate death, but their almost instantaneous decomposition. All my efforts at preserving specimens in Goadby's liquor have entirely failed, and when, under identical circumstances, I succeeded in keeping for a long time specimens of Pleurobrachia rhododactyla, I failed in preserving specimens of Bolina alata longer than twenty-four hours. Again, this species being by no means so common as the Pleurobrachia, with which it is found promiscuously, I had to contend with great difficulties in my investigations of its structure. I nevertheless succeeded several times in injecting it with indigo, and though the injection soon caused the death of the animal and its decomposition, I have been able to trace the circulation for a sufficient time to follow the full course of the fluids within the body throughout all its parts; and being already acquainted minutely with the arrangement of the chymiferous tubes in Pleurobrachia, I was fully prepared to institute between the two genera a minute comparison, to ascertain their differences, and to recognize the homology of their structure. I was even able to trace the connection of all the parts of the chymiferous system more fully in Bolina than in Pleurobrachia, and to ascertain connections between its central and peripheric tubes which I failed to perceive in Pleurobrachia, in which these connections may, however, be wanting to some extent, as has already been mentioned above, when describing Pleurobrachia rhododactyla.

In order fully to understand the structure of Bolina alata, and the relations of its various parts, it is necessary first to have a precise idea of its external form, which it is by no means easy to acquire, even after repeated investigations. Like Pleurobrachia, the body of Bolina is more or less ovate, but in an inverse direction; for its greater diameter follows the plane of the corresponding organs in such a connection as to show

many instances which show that species on the opposite shores of this continent are adapted to the difference which exists in the climatic condition, and the different course of the isothermal lines on the eastern and western sides of the Old and New Worlds.

that the antero-posterior diameter is the longer, while it is the shorter in Pleurobrachia, and *vice versâ*, that the transverse diameter is the shorter, while it is the greater in Pleurobrachia. This inverse agreement between the natural relations of organs and external form is most satisfactorily ascertained, upon comparing the position and direction of the circumscribed area and of the tentacles, and we shall see hereafter that in every respect the proportions of the body with reference to their longitudinal and transverse development are reversed in the two genera. Before this contrast had been established, I was unable to trace the homology of parts between the two genera. Indeed, taking the general form as a guide, I began with comparing the two animals in a position in which I undertook to place their prominent diameters in the same relation, and thus arrived at the conclusion, that the tentacles, which are far less developed in Bolina, and issue from the margin of the mouth itself, were organs differing from the tentacles of Pleurobrachia, which I considered as a system entirely peculiar to that type of Beroe, while the tentacles of the type of Bolina appeared to me as a sort of fringes of the mouth. But the moment I placed the diameters of the two bodies in a position inverse to their length, all parts being placed in the same natural relation as far as they correspond by structure, their perfect homology throughout the system was at once established. And not only the correspondence and antagonism between the anal area and the tentacles, but also the minor details in the ramifications of the chymiferous system, agreed in every respect. The difficulty under which I had labored was precisely that of an artist attempting in a family picture to bring out the resemblance between two kindred faces, while contemplating one individual in profile, and the other in a front view, but believing their position to be the same. With this inverse relation between the homologous parts considered in their reference to form in the two genera Bolina and Pleurobrachia, there is a corresponding opposition between the natural positions of the two animals in the surrounding media. Pleurobrachia, as I have stated, swims naturally with the mouth upwards or forwards, and the anal area downwards or backwards; in Bolina the animal moves with the mouth downwards and the anal area upwards.

The position of the tentacles, their natural relations to the body when in motion, and the direction of the aperture through which they issue, were the chief sources of error which led me first to consider them as different apparatus; for in Pleurobrachia (Plate I.) they are turned downwards towards the anal apertures, while in Bolina (Plate VI.) they are turned downwards towards the oral aperture. But now we may ascertain the homological identity of these appendages, by placing these two animals in the same structural position. It will be easy to understand how, in accordance with the form and movements of the various members of the whole family, the tentacles may issue from different heights

of the vertical diameter upon the sides of the body, and, according to the direction of its movements, be bent either towards the mouth or towards the anus, and thus a foundation for their correct correspondence fairly introduced. Judging from the figures of Mertens, it even appears that in the same genus this direction may be reversed; for in Beroe cucumis the tentacles are bent, and issue in the direction of the anal aperture, as is also the case in B. compressa and B. octoptera, while in B. glandiformis it is the reverse. May not this circumstance, however, coincide with some other differences in the structure of those various species referred to Beroe, and indicate the propriety of separating them generically? Judging from Pleurobrachia when contrasted with Bolina and Cydippe, we might infer that the tentacles were more and more developed in proportion as they are removed from the mouth. But Leucothea shows that oral tentacles may be as extensively developed as those which issue from the sides of the body. It is further a question, which I am not, however, prepared to answer, how far the tentacles of Beroe may be homologized with either the tentacles around the mouth, or those around the disk, of Discoid Medusæ. From their connection with the chymiferous system, I should be inclined to view the complicated branched tentacles of Beroe as corresponding to the marginal tentacles of true Discoid Medusæ, rather than as answering to the fringed lobes which surround the oral aperture in so many of the latter. The position of these tentacles with reference to the mouth bears some resemblance to what is noticed in the position of the anus in the family of Echini, where the anus may open below very near the mouth, or about the margin, or even on the upper surface of the disk, directly opposite to the mouth, without interfering with the general homology of those parts.

After this digression, if we return to a more direct consideration of the form of Bolina, we find that it differs from Pleurobrachia in the extraordinary development of two lobes on its lower extremity (Plate VII. Fig. 1, 2, and 3), inclosing, when shut, the mouth and its appendages, and extending transversely to the antero-posterior diameter, one forwards and the other backwards, so that they contribute when expanded to increase the already prominent length of the longitudinal diameter, leaving a deep transverse fissure between them, at the bottom and centre of which the mouth is situated. The body thus shuts up by the alternate approximation and separation of two valve-like lobes, hanging downwards, placed one in advance and the other backwards, in a position precisely inverse to that of the valves of Acephala, which rest upon the sides of the body, and move laterally. In addition to these two large broad lobes, there are on each side two smaller ones, which arise from the main body at about the same height as the anterior and posterior lobes, but which are simple short, narrow auricles converging or diverging alternately, and thus shutting from the side, and above the great transverse fissure of the

animal. With the power which these animals enjoy of opening widely or shutting closely their anterior and posterior lobes by contraction and dilatation, bringing them alternately close together or stretching them forwards and backwards, the general appearance of the animal is constantly so completely changing, that it requires long acquaintance with them fully to appreciate the connection of all the parts in their different attitudes, and the influence of the movements of certain parts upon the position of others, and upon their functions. The activity of the circulation through the chymiferous tubes, and the position the main branches of the central cavity assume in these different changes of the general form, are constantly modified, as are also the width of the body and the power of its contractions. But in the same proportion that the extent of the longitudinal diameter is modified by the expansion and contraction of the anterior and posterior lobes, the height of the animal, compared to its width and length, is also constantly changing. If we add to this the diversity of images which are brought before us, when we watch these animals in their various movements, from different sides, facing alternately the longer or the shorter diameter, the sides, or the upper or lower surface, I venture to say that it is impossible to make correct descriptions, and to give true representations of such animals, unless they have been watched for a long time in a living state; for it is utterly impossible to examine their forms out of the water, as all parts then collapse, fall together, break in pieces, or dissolve into a shapeless mass. And, although I acknowledge the great interest of the descriptions published by travelling naturalists, making us acquainted with the great diversity of types of these remarkable animals all over the world, satisfactory illustrations cannot be expected from any quarters save those where able observers have resided for a long time, and the accounts of the generic and specific characters of most Medusæ must be considered as provisional, so long as they are not revised under favorable circumstances.

Viewed from above, that is to say, from the anal extremity, with the lobes contracted, Bolina appears very much like Pleurobrachia, assuming then the form of a slightly compressed sphere (Plate VII. Fig. 5); and were it not for the opposite direction of the circumscribed area, which runs in the longer diameter, while it is transverse to it in Pleurobrachia, the identity would be almost perfect. Seen from below, however, (Plate VII. Fig. 6,) even when the lobes are contracted, the difference is already marked, owing to the circumstance, that the vertical rows of locomotive fringes do not extend uniformly from one extremity of the animal to the other, the two ambulacra of the anterior and posterior lobes being much longer than those of the sides, which terminate at about half the height of the body.

Viewed in the same position with slightly opened lobes (Plate VI. Fig. 5), the

difference between the longitudinal and transverse diameter is already more marked. But what is more striking, a considerable portion of the body seems, still further, more elongated than its general outline, and the four lateral lobes, or auricles, appear as appendages to the anterior and posterior lobes. In proportion, however, as the larger lobes expand, the small lateral lobes are successively more and more detached from them, and their real connection with the sides of the main body begins to be apparent, as in Fig. 7, 8, and 9. In this position the greater length of the anterior and posterior ambulacra, and the shortness of the lateral ones, are quite apparent. In proportion as the anterior and posterior lobes are more and more stretched forwards and backwards, their sides assume a more pointed form, similar to the horns of a crescent, or rather to the blade of a tomahawk, and the whole body, from its diminutive size, appears like two tomahawks in miniature placed head to head in opposite symmetrical directions, without handles, the four short lateral appendages looking like two small sticks projecting through the eye of the head for an equal length on both sides.

Seen from below, in the same development of all parts, the general outlines do not differ materially from the view just described, excepting that the mouth is in sight in the centre, extending forwards and backwards in the same plane as the circumscribed area opposite, and the ambulacra appear only indistinctly through the mass. Fig. 6 of Plate VII. represents such a view. The body, however, is sometimes stretched in the longitudinal diameter to such a degree as to give its outline an irregular, oblong-square form (Plate VI. Fig. 10).

Viewed in profile, the body presents also two very distinct aspects when seen by the broad face or by the narrow face, or when examined from its anterior and posterior or from its lateral side. Facing the anterior or posterior end, the symmetry of the figure, as in Plate VII. Fig. 4, arises from the parity and symmetry of the right and left halves of the body; the two sides of the anterior and posterior lobes being perfectly symmetrical. But here, again, the outlines may differ greatly, in consequence of the expansion or contraction of the lobes, which may hang down and look almost straight, with the main mass of the body above, or spread laterally and assume a rounded form, like a broad apron suspended from the chest with projecting auricles or appendages about its point of insertion (Plate VI. Fig. 6). In this position the anterior or posterior pairs of ambulacra are seen in their fullest development, extending from the summit along the middle of the lobe to its lower margin, tapering gradually as the lobes grow thinner.

Seen from the sides, the symmetry of the figure arises from the perfect symmetry and equality between the anterior and posterior extremity of the body, and the outlines

may vary, as the two lobes are pressed nearer together or stretched apart to a greater or less extent. The modifications in this respect are almost endless, as also the manner in which the margins of the lobes fold over; for their lower margin may hang loosely down, as in Plate VII. Fig. 3, or it may bend inwards, curving itself in rounded or square outline, as in Fig. 2, reaching, also, over the sides, or stretching more flatly. In these various states of dilatation or contraction, the lobes may diverge from each other in all possible degrees; one may even overlap the other alternately, and thus reduce to the utmost the difference between the longitudinal and transverse axis, as in Fig. 1. The small lateral lobes, two in number on each side, may, in these various changes of form, assume also the most diversified positions; at times stretching straight downwards, at times arching upwards, at times hanging down, converging towards and even crossing each other; so that there is no end to the diversity of these aspects. I should say, however, that the motions of these lobes, especially those of the two large anterior and posterior lobes, are comparatively very slow and graceful; while those of the small lateral lobes are somewhat more brisk.

Seen from the sides, the pair of lateral ambulacra (Plate VII. Fig. 1 and 2) converge from the upper summit towards the base of the lateral lobes, and the anterior and posterior ambulacra of the same side appear in profile near the anterior and posterior margin, encircling in parallel curves the lateral ambulacra, but extending and gradually tapering all the way down to the lower margin of the lobes.

The whole animal progresses rather slowly, its movements being tremulous, like dancing in slow steps through the water, and now and then revolving upon itself. But we never see those quick, darting motions which characterize Pleurobrachia, nor any thing like the graceful curves of the tentacles following it like a comet's tail, for here the tentacles do not extend beyond the margin of the lobes. And the lobes themselves are an impediment to quick and graceful motion; for the anterior and posterior ones are disproportionate in size to the body. There is, however, an attitude in which the movements of this animal are exceedingly graceful. It is when the lateral lobes are fully expanded, and even recurved forwards and backwards, and so elongated as to appear like two flower-petals spreading in an opposite direction, and curving outwards. In this development the animal generally reverses its position, the mouth being turned upwards, and the lateral lobes also curved outwards, presenting their vibrating fringes in the utmost degree of activity, the whole animal resembling an open white flower, with two large and four small petals revolving slowly upon its peduncle, or changing its place in various directions. Fig. I. of Plate VIII. represents a specimen in such an attitude.

The ambulacra are so closely connected with the appearance of the whole animal and its movements, that we had better consider these first. As in all Beroid Medusæ, they constitute vertical rows of movable fringes, identical in structure in every respect, as far as it has been traced, with those of Pleurobrachia, the difference consisting mainly in their extent, the pairs which run along the anterior and posterior extremities of the body, and extend upon the two large lobes, being by far the longest, and also somewhat wider, their flapping combs tapering gradually towards the anal area, so that the ambulacra terminate in points at some distance from the central black speck. This is equally the case with the two pairs of lateral ambulacra, which, however, extend somewhat farther inwards, the tip of the eight ambulacra encircling an oblong area, the longer axis of which is in the same plane as the circumscribed anal area, which extends, however, far beyond forwards and backwards, between the rows of combs of the anterior and posterior pairs of ambulacra. Another peculiarity which distinguishes Bolina from Pleurobrachia, in the arrangement of this extremity of the body, is the circumstance that the body here is not simply rounded, but somewhat depressed along the longitudinal axis; so much so, that the two sides bulge sensibly above the level of the central speck, while the anterior and posterior extremities are on a level with it. The consequence of this form of the main gelatinous mass of the body is, that the upper extremity of the anterior and posterior ambulacra runs almost straight, while in the lateral ambulacra it is arched over the two rounded parallel ridges which inclose the circumscribed anal area. It is easily ascertained, that eight small tubes, similar to those observed in Pleurobrachia, extend beyond the upper extremity of the ambulacra towards the central black speck, or rather towards the bulb under it, and that they are the prolongation of the vertical ambulacral tubes of the chymiferous system. Below the main bulk of the body, along its sides, the ambulacra gradually taper also towards their lower extremity, and as soon as they reach the height of the dilatation of the lobes, the locomotive combs disappear, and the vascular tubes which accompany them can alone be traced farther. In the lateral ambulacra, however, these combs are reduced much sooner. The rows themselves taper also sooner, and terminate at the base of the small lateral lobes near their inner margin, for a considerable length above the lower extremity of the ambulacra of the large lobes. In the small lobes we trace, also, a narrow prolongation of the chymiferous tubes, which extend beyond the locomotive fringes. The course of these narrow tubes upon the lobes is very difficult to trace, and their connection with each other and with the central chymiferous cavity has been entirely overlooked by former observers, though there are, in the figures of Bolina elegans published by Mertens, indications that he noticed the outline of their convolutions. I shall first trace the course of these tubes

upon the larger lobes. As long as the tubes follow a straight course in the prolongation of the anterior and posterior ambulacra, they remain at the surface of the gelatinous mass, covered only by the epidermis beyond the ambulacra themselves. But as soon as they diverge towards the sides, and approach the lower margin, where they bend to take again an inward course, they penetrate deeper and deeper into the substance, across the whole thickness of the lobe itself, till they reappear upon its inner surface, where they are nearest to each other, then rise, diverging again, and following almost exactly the outline of the lateral margins of the lobes, along which they ascend towards their bases, rising higher than the lower termination of the ambulacral combs, as high as the bases of the short ambulacra, then converge again, bend downwards, and in a sinuous, winding course descend again towards the lower margin of the lobe, remaining nevertheless above the first lower comb, and converging from the two sides immediately in the medial line ; so that there is a direct communication between the right and left ambulacral tube of the anterior and posterior pairs, passing in their course from the margin of the outer surface to the middle of the inner surface, first descending, then rising, then descending again in undulating lines, until they meet to form a central continuous channel. Such a connection between any of the tubes on the oral side of the ambulacral tubes has not been seen in Pleurobrachia ; but, as I mentioned when describing the structure of that genus, I should not be at all surprised if it should be finally found that there is such a connection around the mouth, for there are vascular tubes following the walls of the digestive cavity which reach the margin of the mouth, along the folds of which I have repeatedly thought I saw something like tubes and a current ; but though I could never satisfy myself completely upon this point, and though I have always been unable to trace the ambulacral tubes in Pleurobrachia beyond the oral termination of the locomotive combs themselves, the existence of such minute tubes in the substance about the mouth of Pleurobrachia is rendered very probable, since it is seen here that extensive, and, indeed, even large vessels wind their course in the lobes, and we shall presently see that there is a further communication between those of the larger lobes and those of the smaller lobes, as well as between them and those around the mouth, in its margin and in the tentacular apparatus, so that the circulation of fluid from one summit towards the other, and the recurring movement in the opposite direction, are fairly established by a direct course of tubes in Bolina, though the movement of fluid in these tubes takes place in a backward and forward direction, which therefore does not imply the possibility of a complete want of such communication in Pleurobrachia, where the circulation would be reduced to a forward and backward movement in the main trunk of the system. The ambulacra of the sides are reduced to a simple chymiferous tube as soon as they reach the base of the

lateral lobes, whence the tube continues in a very complicated course through the lobe and towards the mouth, and also towards the large lobe. First, the tube follows the inner margin of the small lobes, then turns round their obtuse points and retraces a parallel course in an oblique direction; but the base branches in such a way as to unite simultaneously with a tube extending along the margin of the mouth, and with another extending into the large lobe, or it may rather be said, that an anastomosis is established at the base of the small lobes, on their external margin, with the chymiferous system of the large lobes, as well as with that of the margin of the mouth. Fig. 3 of Plate VII., in which the inner surface of the anterior lobe is turned outwards for the whole extent of its margin, shows this connection most distinctly. The anastomosis with the large lobe is established through a tube which arises from the lower sinuosities of the inner convolution of the long ambulacral tube. The communication with the oral tube is more direct, and may be considered as a branch from the tube of the short ambulacra; indeed, both may be considered so, the anastomosis with the large lobe, as well as that with the mouth. But, in the first case, the communication with the tube of the long ambulacra is more indirect than it would be if it were placed in the course of its terminal sinuosities, where it forms frequent anastomoses; while the connection with the oral system is direct, through a tube which only bends at right angles upon itself. What is the meaning of these numerous anastomoses upon the inner surface of the large lobes I cannot tell. Are they of the character of the gills of Brachiopods and Ascidians, or are they something of a nature more peculiar to these animals? This remains to be investigated.

But so much is certain for the present, that the large lobes and the small lobes are not fully identical. The large lobes are a mass of the same gelatinous substance which constitutes the principal portion of the body; while the small lobes seem simply membranous, and are really hollow sacs, a kind of *diverticula* arising from a folding of the surface of the body at the lower extremity of the short ambulacra. These lobes are, indeed, a mere fold, and the direct prolongation of the short ambulacra in every respect, though they seem as completely different from the ambulacra as they are from the large lobes. However, upon close investigation of their structure (Pate VIII. Fig. 8), it is found that their margin is encircled by vibrating cilia, and that the ambulacral tube follows the base of those cilia all round the margin of the lobe, until the cilia of the lobe disappear in their turn, and the tube alone is continued, branching, as mentioned above, into the large lobe, as well as towards the margin of the mouth.

Upon these considerations, we may, therefore, view the small lobes as a simple modification of the lateral ambulacra, bent inwards in proportion as the great transverse

fissure which separates the two large lobes rises higher along the sides of the mouth, and thus introduces a loop in the lateral ambulacra, instead of a straight course, as on the sides; the vibratory cilia of the small lobes being modifications of the locomotive combs of the ambulacra proper, which would appear as long on this side as on the other, if they were stretched in the same manner, but which are here folded over in the shape of prominent auricles acting more directly and energetically as lateral oars.

If this view of the four small lobes is correct, we may consider the vertical branch or fork of the vascular tube below as the direct prolongation of the ambulacral tube proper, and the fork which diverges into the large lobes as the anastomotic fork, connecting the ambulacral tubes all round the body. The horizontal branches along the sides of the mouth should then be considered as the anastomotic branches between the two lateral ambulacral tubes of each side, and thus the circle would be made perfect.

There is a great interest connected with a further investigation of the vibratory cilia of the small lobes, in comparison with the locomotive combs of the ambulacra. For the former are so similar to common vibratory cilia, and the latter are so plainly a more advanced system of locomotive apparatus with a complicated structure, and both are morphologically so fully homologous, as to show that, in the series of natural developments, vibratory cilia are not absolutely a specific type of structure, but may constitute, in a gradual development, a natural link, connecting more complicated organs with the simplest fringes of structural cells. I entertain now so little doubt respecting such transitions, that I have not hesitated throughout these descriptions to consider the rows of vertical locomotive fringes as true ambulacra, though there is as great a difference between them and the ambulacra of Echinoderms, as there is between them and simple vibratory cilia. We are thus led to recognize through the whole type of Radiata a natural gradation in the structure of the organs through which currents of water are produced around the body, from the simplest combinations in Polypi to the most complicated apparatus in Echinoderms. In Polypi we have only vibratory cilia arising from structural cells over extensive surfaces of the whole body, while in Beroid Medusæ there are, in addition to such cilia, peculiar rows of fringes, which move by muscular action upon their bases, and in Echinoderms each fringe in the shape of an independent ambulacral type assumes as great a structural complication as the whole system taken together in Acalephæ. The ambulacral tubes in Echinoderms, and the aquiferous system with its vesicles in star-fishes, or the true ambulacral gills in Echini, seem to me, indeed, to bear the same relation to each other, as the fringes of the locomotive combs, with their basal muscles, in Beroid Medusæ, bear to the vertical ambulacral tubes.

If, from this review of the superficial ramifications of the chymiferous tubes, we

proceed to an investigation of their connection with the interior stems and the central cavity of the whole system, we find a very close resemblance in their arrangement to what has already been noticed in the genus Pleurobrachia ; the chief difference between the two genera consisting in their peculiar termination and connections in the peripheric lobes. The centre of the chymiferous system constitutes in Bolina (Plate VIII. Fig. 2 and 9), as well as in Pleurobrachia, a vertical hollow axis, extending from the centre of the anal area down to the sides of the digestive cavity, being, however, not so spacious as in Pleurobrachia, while the digestive cavity itself is larger, extending nearer the central black speck, so that the funnel which branches towards the circumscribed area below the tubercle of the black speck is shorter, the main cavity from which the main trunk to the ambulacra arises being much narrower, and the tubes extending towards the margin of the mouth, along the lateral walls of the digestive cavity, being in the same proportion longer. But the general arrangement is identical. The differences exist only in the proportional development of the different parts of the whole system, as also in the curve of the ambulacral branches, which are more strongly bent upwards, instead of stretching horizontally across the gelatinous mass. Owing to the lesser development of the central cavity of this system, and the difficulty of preserving alive these animals after injecting colored liquid into the chymiferous sac, I have not succeeded in discovering a regular contraction between the right and left sides of the system. It may be, also, that the transverse diameter, being so much shorter in this genus than in Pleurobrachia, and the means of establishing a retrograde current from the periphery much more extensive, the circulation takes place through alternate dilatations and contractions of the whole body, causing an injection of the fluid in all directions, rather than by an alternate passage from one side into another ; and for various reasons of analogy I incline rather to this view. In the Discoid Medusæ, we have an absolutely radiating circulation, and a movement simply to and fro from the centre to the periphery, and back throughout the whole system. In Pleurobrachia there is an alternation between right and left, with a prominent circulation to and fro. In Bolina, there is also a bilateral symmetry, but the radiating circulation seems to be recurring in itself through a complete circle, which arrangement would already approximate the Beroid Medusæ of the genus Bolina to the type of Echinoderms, though in a lower condition of the circulating system.

Whatever may be the value of these suggestions, so much is plain, — that the digestive cavity constitutes a capacious sac with a longitudinal mouth, the fissure of which opens in the same plane with the anal area, precisely as in Pleurobrachia, in a gelatinous, oblong disk, extending with its longer diameter flat between the anterior and posterior lobes (Plate VIII. Fig. 6). This disk is entirely surrounded by the large lobes when they are

shut, but it forms the lower outline of the body when the lobes are entirely open and fully spread. In this attitude the mouth is shut, but the lobes are wide open, to inclose any food that may come within reach; and whilst dropping fragments of oysters upon them, as they are generally turned mouth upwards, in this extreme state of dilatation, I have sometimes seen the lobes close upon such morsels to secure them, and afterwards the mouth expand and open within to swallow the food, the tentacles being alternately drawn out and retracted.

The visible outline of the digestive cavity changes most remarkably in these various operations. When the mouth is shut, and the digestive cavity is empty, the digestive sac is completely flattened and compressed in the direction of the longer diameter, rising like a tapering funnel towards the central chymiferous cavity above; that is to say, the fold of the digestive sac which is stretched between the antero-posterior angle of the mouth converges towards the upper extremity of the body, and the flattened walls are pressed upon each other. In this position, the vertical chymiferous tube runs downwards, and along the middle of the outer surface of the digestive cavity, and reaches, near the lateral margin of the mouth, the sac of the tentacles. But after food has been swallowed, and the mouth is contracted into a more sphincter-like shape, and the digestive cavity so much narrowed above its external fissure, that the cavity of the digestive sac appears like a loose bag widest about half its height, with prominent angles in advance and backwards, swollen also laterally, but tapering above and below. In such a state the vertical chymiferous tubes of the sides have a more curved and even sinuous course, in accordance with the position of the morsels of food within, and the upper end of the digestive sac opens freely into the central chymiferous cavity.

I have seen distinct indications of fibres in the walls of this sac. There are also marked vertical folds along its upper end, of a brownish color, darker than the transparent walls of the other parts of the sac. But I have failed to see distinctly the vibratory cilia of the upper opening, though there is a constant movement of the minute particles of digested food about the aperture of the digestive cavity leading into the chymiferous cavity.

As mentioned above, this central chymiferous cavity is not only shorter, but also narrower, in the genus Bolina than in Pleurobrachia, though the fibrous structure of its wall is much more distinct. It has also a somewhat different form, though the same disposition, its sides bulging simply outwards, instead of forming two distinct trunks for the branches to the ambulacral tubes, as in Pleurobrachia; so that the four main branches arise in pairs almost directly from the main cavity, the tubes of one side, however, at greater distances from each other than the two corresponding anterior, or the two cor-

responding posterior ones, owing, no doubt, to the lateral compression of the body. And from the wider space between the two main branches of one side arise again the vertical tubes, which descend along the digestive cavity, towards the base of the tentacles.

Again, the four main branches of ambulacral tubes, instead of stretching horizontally towards the ambulacra, are bent upwards, and then divide each into two branches, to provide the eight ambulacra with as many vertical ambulacral tubes. The consequence of this arrangement is, that the impulse of the liquid pressed into the ambulacral tubes is chiefly in one direction, the branches from the main cavity meeting the ambulacra near their upper termination, and not at about half their height, as in Pleurobrachia. So that the chief current, and, I may say, almost the only constant current, is downwards along the sides, following the ambulacra, and all the sinuosities of their tubes in their lower course through the great lobes, as well as through the lateral auricles; and a comparatively very small portion of fluid flows towards the upper centre, through the very thin tubes extending from the upper summit of the ambulacra towards the anal area. The main antagonism between the currents, therefore, is between the upper and lower extremities of the body, and by no means between the right and left side, and *vice versâ*. Whether, however, the retrograde movement takes place upwards, through the same tubes in which it has moved downwards, or whether the winding course of the narrow tubes in the lobes constitutes a kind of capillary system, through which the liquid passes from one side of the ambulacral tubes into the other, I am unable to decide. But I cannot help thinking that this long winding course of the ambulacral tubes, upon the inner surface of the large lobes, and along the margins of the auricles and mouth, contributes to a more extensive aeration of the chyme in circulation than the straighter course in the wider vessels of the whole system in Pleurobrachia. But perhaps the more active alternate contractions in Pleurobrachia compensate by their quicker movements for the deficient ramification of the tubes themselves, which is so extensive in Bolina.

Of the narrow tubes about the anal area, I shall have to speak again presently. I shall only add here, that the vertical tubes upon the sides of the digestive cavity enlarge near the middle of the lateral margins of the mouth into a small, bulb-like dilatation, from which a bunch of tentacles may be issued or retracted. But this bulb is by no means so complicated as the tentacular sac of Pleurobrachia. There is no flat disk with elastic springs, but simply two narrow tubes arising from the main cavity, a little outside of the tubes of the digestive cavity, and following its course to the tentacular bulb. As, on account of the lateral pressure, the tubes of the digestive cavity and those of the tentacular bulb are brought into close contact, they appear at first sight

to constitute a single cord on each side; but in reality that cord consists of three tubes running in the same direction, which, being close together, are very easily mistaken one for the other, and whose natural connections are still more difficult to ascertain, as the bulb of the tentacle exactly covers the termination of the tube, resting immediately upon the digestive cavity and extending to the margin of the mouth. But whenever, by an oblique movement of the margin of the mouth, or by the dilatation of the tube, one way or the other, out of the vertical direction, the superposition of the bulb of the stomachal tube is disturbed, it must be seen how the tube of the digestive cavity divides into two horizontal branches, extending in opposite directions along the lateral margin of the mouth forwards and backwards, at right angles with the tube from which they arise, so that a direct communication is here established between the peripheric course of the ambulacral tubes and the main central cavity, a communication which very likely gives passage to the recurrent fluid, which does not return through the same tubes in its course. As for the two small tubes which unite in the bulb of the tentacles, they arise from the same lateral bulging of the same cavity from which the lateral tube of the stomach originates, but they arise more vertically.

The greater simplicity of the tentacular bulb has reference, no doubt, to the shortness of the tentacles, and to the circumstance that they are not protruded to any length beyond the margin of the mouth, but simply extend in a winding course forwards and backwards along that margin, forming, when contracted, a compact bunch, and appearing, when expanded, like a disorderly brush of irregular curled threads tied together on one side.

The best position in which to study the ramifications of the tubes on the side of the digestive cavity along the outer margin of the mouth, and the position of the tentacular bulb still farther outward, is when the animal is turned mouth upwards, with its large lobes fully expanded, when the mouth appears like a narrow rim in the centre of the prominent gelatinous mass between the large lobes which constitute a sort of compressed isthmus between the antero-posterior extremity of the body, along the margin of which the horizontal tubes from the stomachal tube are seen to extend as far as the right margin of the lateral auricles, without entering into direct communication with the tubes of the tentacular bulb. See Plate VIII. Fig. 6.

The walls of the central chymiferous cavity, and the main trunks which arise from it, are distinctly fibrous, and may easily be seen to shorten or elongate, and enlarge or contract their cavity.

The funnel enlarges above into two distinct branches, forming two bulbs, as in Pleurobrachia, with oblique openings forwards and backwards, on the sides of the circum-

scribed area, and with the black speck in the centre. This black speck has also a distinct ring, and it has seemed to me almost evident tha this ring extends, in the form of narrow tubes, along the margin of the circumscribed area, and also that the eight narrow tubes converging from the summit of the ambulacral combs empty into this ring; and as the ring itself is a fold from the prolongation of the funnel into the cavity extending forwards and backwards under the circumscribed area, it would follow that these eight tubes communicate here with the central chymiferous cavity, as they communicate from below through the tube around the mouth, an arrangement which would complete the circulation, the main movement of which would seem to follow the ambulacra downwards, with a small eddy upwards towards the eye-speck, and with a main recurrent stream along the digestive cavity. I should add, that the relative position of the eight narrow tubes from the ambulacra, where converging towards the anal area, differs considerably between the different pairs, the two anterior and the two posterior ones being very near together, almost in the longitudinal axis; and the two tubes of the two lateral pairs being, on the contrary, as far apart from each other as they are from the anterior pairs. So that there seems to be only six tubes meeting the central funnel, when in reality the anterior and posterior are each double.

I have not succeeded in making out a distinct nervous system connected in any way with the central tubercle, though numerous fibres diverging in all directions may be seen in connection with the upper part of the funnel. But it has always seemed to me that they are rather muscular fibres than nervous threads, for they change their length, and are by no means so symmetrically arranged as might be expected in a nervous system in these animals, when we know its disposition in other types of the class. This region, however, and the periphery of the mouth, are the places to look for it. But notwithstanding all efforts, I confess I have failed in the search.

With regard to Pleurobrachia, I have already expressed my opinion respecting the organic nature of the central black speck, which presents precisely the same appearance in Bolina, and the same general relations with the surrounding parts right and left, forwards and backwards, and below. The bulb below seems to me really to be simply a central projection of the chymiferous cavity, the ring around it something like the ring of Sarsia around its central tubercle, and the eight narrow tubes diverging from the summit homologous to the four vertical tubes of the Naked-eyed Medusæ, the whole differing only by the presence of apertures through which the refuse matters are discharged from the chymiferous cavity.

The extraordinary transparency of the gelatinous mass, and the impossibility of preserving the animal after death in a contracted state, forbid the prospect of ever knowing

fully the arrangement of the contractile fibres throughout the body. The general arrangement is very probably the same as in Pleurobrachia; for in some dying specimens, I have seen, at some distance from the central black speck, eight points between the ambulacra, alternating with them, arranged, as in Pleurobrachia, in the form of an oval, which indicate probably the presence of as many vertical bundles of fibres running from the upper summit downwards, and regulating the movements of the lobes jointly with circular fibres, which are more easily detected, and occur in great numbers grouped together in bunches along the sides of the vertical rows of locomotive fringes in the space intervening between their combs, and extending brush-like horizontally into the substance, though diverging in each bundle. These fibres seem more powerful, and, at all events, far more distinct, than the vertical muscles, which I have never been able to trace in continuous rows. Some means might perhaps be found to preserve their bodies in such a way as to bring out the muscular fibres. It would, indeed, be very interesting to study their arrangement, especially with reference to the motions of the large lobes.

Though I have watched specimens of this species at short intervals through six successive months, from December to June, I have never succeeded in discovering the sexual system, not even in the most rudimentary state. Should it, however, be found to follow in its development the course of the ambulacral tubes, as reported by Wild, this fact would go far to show the homology, to which I have above alluded, between the ambulacral tubes of Beroid Medusæ, and the vertical chymiferous tubes of Naked-eyed Medusæ. The circumstance of my failing to trace the reproductive system after so long a search, may show how great difficulty these investigations are attended with, and how much remains to be done before the whole history of these animals is satisfactorily made out.

Of their embryonic development nothing at all is known; but from the character of the black specks, I would repeat what I have said of Pleurobrachia, that I suppose them to be developed from Hydroid Polypi.

I have observed a third Beroid Medusa on the shores of Massachusetts, in Edgartown harbour and at Nahant, belonging to the genus Idya, but it was under such circumstances that I could neither examine it carefully, nor have drawings of it made to my satisfaction. I may say, however, that this species, at least in the condition in which it was observed, is much smaller than any of those described before. I regret the more to have been prevented from making a minute investigation of it, as that genus is particularly remarkable for the lateral ramifications of the ambulacral tubes, and it would be very important to compare these ramifications with the radiating ramifications of the chymiferous tubes in Discoid Medusæ.

The extraordinary metamorphoses of star-fishes and Echini, which Professor Müller first observed, ought not to be neglected in the study of Beroid Medusæ; for the remarkable resemblance between the singular transparent frame which protects the growing embryo of the star-fish and the body of Beroid Medusæ cannot be overlooked by an attentive observer; and the fact, that the parts of that external frame present numeric combinations which are unusual among Echinoderms, but which correspond to those of the Beroid Medusæ, will be an inducement to institute, at some future day, a close comparison between their structure and that of the Beroids. The ciliated appendages which hang downwards in those animals resemble closely the vertical rows of locomotive fringes with their chymiferous tubes, as observed in Beroid Medusæ. And it is interesting to find hat in Echinoderms there is a metamorphosis going on in the embryo, recalling the structure of the inferior class of Acalephæ in a manner very similar to the analogy which exists between the embryos of Medusæ and Polypi. For whether we compare the Strobila in its earliest conditions, or the young buds of Hydroid Polypi when producing Medusæ, the analogy of this earliest state of development of Acalephæ with Polyps is unmistakable, and I have no doubt that the external frame of the young Asterias and Echini, which Professor Müller has so beautifully illustrated, will be found to bear the closest resemblance to the structure of Beroid Medusæ, as soon as an actual comparison can be instituted with reference to the analogy of their structure, which is far more difficult to trace from descriptions and figures, however accurate these may be; but Professor Müller's attention seems not to have been attracted by this remarkable analogy, which he might have traced so fully when studying these embryos. So much, however, may be said already, that the general arrangement of the ciliated lobes of Plutus corresponds to the ambulacral rows of Pleurobrachia and Bolina, and that the tubes which accompany them compare closely with the vertical chymiferous tubes of the same Medusæ. Notwithstanding my efforts to observe the various developments of Asterias, I have, up to this time, been able to trace their growth only in the peculiar forms first described by Sars.

EXPLANATION OF THE PLATES.

The genera Pleurobrachia and Bolina, though apparently closely allied, and differing chiefly in the development of gelatinous lobes in the genus Bolina which do not exist in Pleurobrachia, present peculiarities which require the most careful comparison in order fully to understand their true relations. It has appeared to me, on that account, very desirable to mark the different parts in both with corresponding letters, in order to prepare the reader for the closest comparison, and a true estimation of their different direction in the surrounding medium. The different bearing of the separate rays, the difference in length of their longitudinal and transverse diameters, the inverse position of the mouth in their normal attitude, the apparent transposition of the tentacles, which seem turned towards the circumscribed area in Pleurobrachia, while in Bolina they accompany the main cavity of the edge of the mouth, are so many features in their structure which cannot be fully appreciated in their respective differences, unless the different species are placed in an identical position when compared. I have, therefore, assigned definite numbers to the different rays or rows of combs and radiating tubes, and marked them with corresponding figures, so as to enable the reader to institute the comparison, either by inverting Pleurobrachia, mouth downwards, to give it the same position as that which is normal in Bolina, or inverting Bolina, mouth upwards, in order to compare it in the same attitude as that in which we usually observe Pleurobrachia when moving. But I may repeat what has already been mentioned above, that occasionally both species may be observed in an attitude the reverse of that which they usually assume.

Before remarking upon the figures which fill the plates accompanying this paper, it will facilitate such comparisons, and the understanding of the individual figures, if I proceed first with an explanation of the letters with which the different parts are marked, which are precisely the same for all the figures in both genera.

A, B. Gelatinous lobes encircling the mouth, so large in Bolina as to form the greater bulk of the body. The two lobes, as developed in Bolina, are opposed to each other in the axis of the plane of the circumscribed area and of the mouth, so that they open and shut against the extremities of the longitudinal fissure of the mouth.

a. The mouth. It assumes the most diversified outlines when shut or expanded in various ways.

b. The narrow tube of the anterior part of the alimentary cavity, being a sort of gizzard or special division of the alimentary canal corresponding to the anterior portion of its tract in other animals.

c. The lower division of the alimentary cavity, performing simultaneously the functions of a stomach and those of a colon; for upon its walls we observe brown hepatic cells, but at the same time there is at its bottom an opening, through which the substances which have been digested are emptied into the main cavity of the body, *d*. This whole digestive cavity hangs free in the main cavity, and is truly the analogue of the alimentary sac of Polypi, as observed in Actinia, and may also fairly be compared with the alimentary cavity of Echinoderms, especially with that of star-fishes; though here the sac may be closed, as it never is in our jelly-fishes, or may empty outside of the animal, while in our Medusæ it empties into the main cavity.

d. The main cavity of the body, in which the products of digestion are circulated, mingled with water. This cavity corresponds truly to the main cavity of Polypi, with this difference, that in Polypi there are only partitions dividing it off around the periphery, while in Medusæ the gelatinous mass of which the body consists fills, to a great extent, the inner space of the animal, and leaves only tubes for the peripheric circulation of the fluid contained in it. There is one vertical prolongation, *f*, of this main cavity, extending in the direction of the circumscribed area, and which branches into two forks, *f'*, *f''*, at its termination. The other tubes arising from it are the two main chymiferous horizontal tubes, *e*, *e*, with their branches, *q*, *q*, and their eight terminal forks, *i*, *i*, which open into the vertical tubes, *v*, *v*. The tubes *r*, *r*, which follow the walls of the digestive cavity, arise also from it near the main horizontal trunks, and from these latter arise the tubes of the tentacular apparatus, *a*, *a*.

e, *e*. The main horizontal trunks of the chymiferous tube, from which arise the eight radiating branches.

f. The vertical, funnel-like prolongation of the main cavity of the body.

f', *f''*. The two forks of that funnel. It should be remarked that the direction of that fork is in the plane of the longest diameter of the circumscribed area, which is also the direction of the longitudinal diameter of the mouth.

g. The roots of the tentacle.

h, h^1, h^2. *h* designates the whole tentacular apparatus, with all its complicated parts, h^1 being the tentacular apparatus of one side, and h^2 the tentacular apparatus of the opposite side. And these numbers are appropriated to the same apparatus in every figure, whatever may be the position in which the animal is observed. It will be noticed that these tentacles are placed at right angles with the plane of the mouth and the circumscribed area.

i. The eight horizontal tubes of the chymiferous apparatus which reach the vertical tubes, following the vertical combs. In all the figures the horizontal tubes are numbered in the same way, beginning with No 1 and ending with No. 8. Number 1 is assigned to that tube which extends to the vertical comb in sight on the left hand when the mouth is turned upwards and the tentacular apparatus appears symmetrically on the right and on the left; so that i^1, i^2, i^3, i^4 are the four horizontal tubes of one half of the body, and i^5, i^6, i^7, i^8 are the four horizontal tubes of the opposite half. And if the view I have taken of the diameters of these animals is correct, that the longitudinal diameter of the mouth divides the body into symmetrical halves, one right and the other left, the tubes i^1 to i^4 are the tubes of the anterior half of the body, and the tubes i^5 to i^8 are the tubes of the posterior half, and the tubes i^2, i^1, i^8, i^7 are the tubes of the left side, and the tubes i^3 to i^6 are those of the right side, or *vice versâ*, as we can only establish these general relations between the different diameters without determining strictly which is the anterior and which is the posterior edge of the mouth. It is probable, however, that no distinction is intended in the structure of these animals, as they are capable of assuming inverse positions, mouth upwards and mouth downwards, in which case the edges of the mouth appear in an inverse position.

j indicates the cavity in which the tentacular apparatus is suspended, and to the inner wall of which it is attached. This cavity opens in *j'*, and through this opening the tentacle may be extended; but it is also capable of such contraction as to be entirely withdrawn within the cavity *j*.

j'. Opening of the tentacular cavity, through which the tentacle is protruded.

k. The main stem of the tentacle from which the fringes arise.

k'. Fringes of the tentacles which arise uniformly upon the same side, the outside of the tentacle, so that they are stretched in opposite directions from the two sides. But this direction is constantly modified in the various attitudes and the various degrees of elongation of the tentacles, as these are capable of being twisted upon themselves; so that the fringes may appear as forming a spiral upon the main stems, or may be stretched in all possible directions, in their more or less extensive elongations. However, at the base they arise strictly in opposite directions.

l, *l*. The vertical combs of locomotive fringes, of which there are eight of uniform length in Pleurobrachia, but four longer and four shorter ones in Bolina. These vertical combs are numbered in the same manner as the horizontal tubes which open into the vertical tubes accompanying the combs, and these numbers correspond in the different figures, in the same manner as in the tubes; l^1 to l^4 being the combs of one extremity, and l^5 to l^8 those of the other extremity, and l^2, l^1, l^8, l^7 being the combs of one side, and l^3 to l^6 the combs of the other side. Upon close examination, it will be found that the short combs in Bolina correspond to l^1 and l^8 of one side, and to l^4 and l^5 of the opposite side, of Pleurobrachia; that is to say, the short combs on the right and on the left side of Bolina embrace respectively the tentacular apparatus of the right and of the left side.

m represents the muscular apparatus surrounding the mouth; *m* indicating the radiating fibres through the agency of which the mouth is opened, and *m'* the circular fibres which shut it.

n represents the main vertical muscular bundles, alternating with the vertical rows of combs. Towards the circumscribed area, these rows assume a more pennate arrangement, which is designated by the letter *t*. Other fibres also diverge around the opening of the cavity containing the tentacular apparatus, and form a sort of constrictor, *p*.

o. Pennate bundles of muscular fibres attached to the sides of the vertical rows of combs and penetrating more or less into the substance of the gelatinous mass.

p. Horizontal bundles of muscles extending between the vertical rows of combs and the main muscular bundles.

p'. Diverging fibres of the main muscular vertical bundles, forming a kind of sphincter around the tube leading into the cavity of the tentacular apparatus.

q. The main trunk from which the eight radiating chymiferous tubes arise. It should be noticed that these tubes are not strictly in the same horizontal plane, since their respective position varies more or less in the different contractions of the body, and those on one side are successively higher than those of the opposite side in the alternate contractions of the opposite halves of the body, which regulate the general circulation of the nutritive fluid.

r. The chymiferous tubes following the digestive cavity. They arise from the main horizontal tube, and extend to the margin of the mouth, following the middle of the flat surface of the digestive cavity.

s. Eight narrow tubular prolongations of the vertical chymiferous tubes, which taper at the summit of the vertical rows of locomotive combs, and extend towards the centre of the circumscribed area, where they empty into the vertical funnel of the main chymiferous cavity.

t. Prolongation of the main vertical bundles of muscular fibres towards the circumscribed area, which follow the course of the narrow prolongation of the vertical chymiferous tubes, diverging like pennate muscles.

u. Combs of locomotive fringes.

v. Vertical chymiferous tubes, which accompany on the inner surface the rows of locomotive combs.

v'. Areolar space upon the inner surface of the vertical chymiferous tubes, from which the eggs are probably developed.

w. Base of attachment of the locomotive combs, from which the isolated fringes arise, and to which the muscular fibres moving these fringes are attached.

x. Ganglion, probably of a nervous character.

y. Ganglion-like bodies, arising probably from the accumulation of granules in the contracted state of the vertical chymiferous tubes when the circluation has ceased.

z. Free granules moving in the vertical chymiferous tubes.

a. Chymiferous tubes of the tentacular apparatus.

a'. The opening through which the vertical chymiferous tubes of the tentacle open into the main horizontal chymiferous tubes between their main forks.

β. Swollen margin of the elongated disk from which the tentacles arise.

γ. Medial keel arising from the summit of the elongated disk of the tentacle, and extending to the base of the tentacle itself.

δ. Eye-speck in the centre of the circumscribed area.

ε. Circumscribed area.

ε'. Raised line following the inner outline of the circumscribed area, probably the analogue of that row of fringes so conspicuous within the circumscribed area in some other genera of Beroid Medusæ, and particularly distinct in the genus Idya.

ε''. Another line parallel to the former, and within it, the special nature of which I have failed to ascertain.

ζ. The openings of the two bulbs of the vertical funnel through which the fecal matters are occasionally discharged.

η. Revolving bulb of fecal matter.

θ. The tubercle upon which the eye-speck, *δ*, rests.

ι, *κ*. Concentric swellings connected with the ganglion of the eye-speck, stretching in the direction of the longitudinal diameter of the circumscribed area.

λ. Four ganglionic swellings within the inner of the swollen margins near the ganglion of the eye-speck, the nature of which I have also failed to determine.

μ. Longitudinal muscular fibres of the main thread of the tentacle.

ν. Longitudinal fibres of the fringes arising from the sides of the tentacle extending across the main thread, where they appear as transverse fibres.

ξ. Coating of heterogeneous cells all round the main thread and its lateral fringes. The larger ovate cells are lasso-cells.

π. Prolongation of the vertical chymiferous tubes extending from the oral extremity of the short rows of locomotive combs to the auricles, and following the inner margin of the latter.

π'. The returning tube following the outer margin of the auricles, and anastomosing with tubes from the inner surface of the large lobes, ϕ, and also with tubes, υ, arising from the margin of the mouth.

ρ. Prolongation of the vertical chymiferous tubes, extending from the anal extremity of the long vertical rows of locomotive combs upon the outer surface of the large lobes.

ρ'. The same tubes turning upwards and inwards.

σ. The prolongation of the same tubes upon the inner surface of the large lobe, winding again in an opposite direction, and forming several sigmoid curves.

τ. The extremity of the same tubes extending again downwards parallel with the corresponding tube of the opposite side, both meeting upon the median line in τ'. From these tubes arises a network of tubes, forming more or less rectangular meshes, — perhaps a sort of gill, ω, from which arises a recurrent tube, ϕ.

υ. Tubes arising along the margin of the mouth from the vertical chymiferous tubes, r, which accompany the main digestive cavity.

ϕ. Recurrent tube arising from the margin of the internal network of vessels which spreads over the inner surface of the large lobes. This tube, following a course parallel to the edge of the large lobes, anastomoses near the base of the auricles with the recurrent chymiferous tubes, π, of the auricles, and the tubes, υ, from the margin of the mouth.

χ. Auricles, four in number, corresponding to the short vertical rows of locomotive fringes, and therefore analogous to the vertical rows l^1, l^8, l^4, l^5. In accordance with this correspondence, the auricles are respectively marked $\chi^1, \chi^8, \chi^4, \chi^5$.

ψ. Vibratile ciliæ along the auricles.

ω. Vascular network upon the inner surface of the large lobes.

Plate I. — Various Attitudes of Pleurobrachia.

Fig. 1. A specimen in a state of rest, the tentacles hanging loosely downwards partly expanded, partly contracted into irregular tubercles; the fringes not expanded. The position of the specimen is such as to correspond to Fig. 3 of Plate II.

Fig. 2. A specimen with the body in nearly the same position, but bending obliquely forwards, the tentacles fully out, the fringes also expanded, except those near the base of one of the tentacles, which are partly contracted.

Fig. 3. A view similar to that of Fig. 1; the body, however, slightly turned upon the corresponding vertical axis, so that the three posterior vertical rows of locomotive fringes, which are not observable in Fig. 1, appear through the transparent gelatinous mass.

Fig. 4. Another view, in which the body has the position of Fig. 1 in Plate II.; one of the tentacles is contracted, the other fully expanded.

Fig. 5. View from the oral side of the body, corresponding to Fig. 5 of Plate II. The tentacles fully expanded.

Fig. 6. A view similar to that of Fig. 1; the body, however, very much elongated, moving forwards, the tentacles fully expanded.

Fig. 7. A view of the animal with the body also elongated, moving horizontally, the profile corresponding to that of Fig. 4; the tentacles stretching at right angles; one with all the fringes out, bending upon itself, while the other is partly contracted, with only a few of the fringes expanded.

Fig. 8. A specimen with the body horizontal, the tentacles considerably expanded. This figure corresponds to Fig. 7, where the elongation of the body has ceased.

Fig. 9. A view of the animal nearly in the same attitude as in Fig. 1, but slightly turned more upon its vertical axis. The tentacles slightly expanded; the fringes drawn in, the extremity of one of the tentacles coiled upon itself.

Fig. 10. A view from the side opposite to the mouth; the circumscribed area in the centre, but somewhat bent upwards, in order to show the branches of all the horizontal chymiferous tubes. The tentacles are in the utmost state of elongation.

Fig. 11. An oblique view, partly profile, partly from the side of the mouth. The parts in sight correspond to Fig. 2, only in an inverse position; the tentacles moderately expanded.

Fig. 12. A specimen moving downwards. The organs in sight correspond to Fig. 3, but in an inverse position; the tentacles slightly expanded, one of them coiled upon itself for some length, with a few fringes expanded.

Plate II.

Fig. 1. *Pleurobrachia rhododactyla* in a vertical position, the main cavity and the digestive cavity in sight from its narrow surface, and the tentacular apparatus right and left. Fig. 5 gives a view, from the side of the mouth, of all parts in the same respective position; and Fig. 4, another view from the opposite side, where the circumscribed area is seen in the centre.

Fig. 2 represents the same in profile, but in a position at right angles with that of Fig. 1, so that the main cavity of the body is seen from its broad surface, and one of the two tentacular apparatus in the centre of the figure. To bring Fig. 4 and 5 to agree in position with Fig. 2, they should be moved 90° upon their axes.

Fig. 3 gives another profile view intermediate between that of Fig. 1 and that of Fig. 2; so that the two tentacular apparatus are in sight, but in an oblique position forwards and backwards, and not right and left, as in Fig. 1, or in the centre, as in Fig. 2.

Fig. 4, 5. To bring Fig. 4 and 5 into the same position, they should be turned 45° upon their axes.

Fig. 6. A part of one of the vertical rows of locomotive combs, behind which is seen the vertical chymiferous tube, into which opens one of the horizontal radiating tubes.

Fig. 7. A portion of one of the vertical chymiferous tubes, the fringes of the locomotive combs being removed to show the bases of the latter, and the ganglia behind them.

Fig. 8 represents half the width of a vertical chymiferous tube, with muscular fibres behind it, and the granules circulating in its cavity.

Fig. 9 represents a portion of a vertical chymiferous tube similar to that of Fig. 7; but the tube is more contracted, and its walls so folded longitudinally as to present distinctly several parallel waving lines, which have no existence in reality when the tubes are fully expanded, but appear only when the tubes are separated from the body, and empty. The same lines appear also in Fig. 7.

Fig. 10. The mouth widely open, with the muscles which open and shut it around.

Fig. 11. The mouth when fully shut.

Plate III.

Various figures to show the course of the chymiferous tubes, the relations between the alimentary cavity and the main cavity of the body, and the connection of the tentacular apparatus with the chymiferous tubes. To render the figures more distinct, the fringes of the vertical rows of the locomotive combs have been omitted. The chymiferous tubes and the main cavity of the body are shaded. In Fig. 6 and 7, however, the shaded parts represent the digestive cavity.

Fig. 1. Corresponding in position to Fig. 2 of Plate II., and showing the connection of the four vertical chymiferous tubes of one side with the main horizontal chymiferous tube, the vertical funnel, the tentacular apparatus, and the vertical chymiferous digestive cavity.

Fig. 2. Corresponding in position to Fig. 1 of Plate II., and therefore placed in a position at right angles with that of Fig. 1, to show the relations of the chymiferous tubes and the main cavity in that position.

Fig. 3. The same parts seen from the side of the circumscribed area.

Fig. 4. The same parts seen from the side of the mouth.

Fig. 5. The tentacular apparatus in its cavity, to show the origin of the tentacle and the connection of the vertical chymiferous tubes of the tentacle with the main horizontal tube, and its branching forks.

Fig. 6. The digestive cavity entirely empty, and flattened in the position of Fig. 2.

Fig. 7. The same cavity, more expanded. In *c*, the brown cells at the lower extremity of the cavity give its surface a peculiar appearance.

Fig. 8. The vertical chymiferous tubes of the tentacular apparatus, in their connection with the main cavity, the horizontal tubes, and the funnel, are represented in an ideal outline, without any part of the tentacles themselves.

Fig. 9. One bulb of the vertical funnel seen from its narrow side, to show a ball of fecal matter accumulating near the opening of that cavity.

Plate IV.

This plate represents the general appearance of the body of Pleurobrachia enlarged and in various attitudes, and gives also several longitudinal and transverse sections of the body, to bring out more fully the relations between the different parts.

Fig. 1 represents the animal in the same position as Fig. 3 of Plate II.

Fig. 2 shows the animal in the same position as Fig. 1 of Plate II.

Fig. 3 represents it in the same position as Fig. 5 of Plate II.

Fig. 4 represents it in the same position as Fig. 4 of Plate II.

Fig. 5 represents it in the same position as Fig. 2 of Plate II.

Fig. 6 and 7. These transverse sections correspond to the line A B of Fig. 2, which letters (in this figure) have no reference to the lobes of Bolina and the swellings around the mouth of Pleurobrachia, marked also A and B.

Fig. 8 represents a vertical section in the position of Fig. 2.

In all these figures the cavities shaded with black lines are the chymiferous cavities and chymiferous tubes. The main stems are cross-barred wherever they are cut, in the section, and the openings of the chymiferous tubes are also cross-barred. The cavity of the tentacular apparatus is marked in addition by lines of dots. On contrasting Fig. 6 with Fig. 7, it will be perceived that Fig. 6 corresponds to a section across Fig. 2 at A, passing through the upper part of the tentacular apparatus; so that the tentacular cavity forms a crescent-shaped opening around the tentacular apparatus. The lower part of the cavity is marked by dotted lines, as are also the horizontal radiating tubes seen below. In Fig. 7, which is a section corresponding to B of Fig. 2, the lower part of the tentacular cavity is laid open at a point where it is occupied internally only by the tentacle itself, and all the radiating tubes and the fringe of the vertical funnel are in sight. In Fig. 8, the digestive cavity and the main cavity of the body, and the whole tentacular apparatus, are laid open by a vertical section, and the position which the tentacular apparatus holds within its cavity is fully displayed.

Plate V.

This plate represents various structural details of Pleurobrachia more highly enlarged.

Fig. 1. Part of a tentacle contracted, and the fringes arising from one side. The two fringes on the opposite side are simply displaced by pressure.

Fig. 2 represents the structure of the tissue under the vertical chymiferous tubes, where it consists of large, irregular cells, probably an ovary.

Fig. 3, 4, 5, 6 represent the mouth in various degrees of dilatation, assuming different forms, sometimes quite irregular, as in Fig. 3 and 4; sometimes elongated, as in Fig. 5; sometimes funnel-shaped, as in Fig. 6.

Fig. 7. The mouth in this figure is entirely shut, assuming a longitudinal form, which, in its direction, corresponds to the direction of the circumscribed area.

Fig. 8 represents a small portion of a tentacle greatly enlarged, to show the structure of the main stem and that of the fringes.

Fig. 9 represents the circumscribed area, the bulb of the eye-speck, and the two bulb-like dilatations of the vertical funnel.

Fig. 10 represents the bulb of the eye-speck, and the surrounding parts still more enlarged.

Plate VI.

Various attitudes of *Bolina alata* of the natural size.

Fig. 1 shows the animal as seen in profile. The two lobes, which are entirely shut, appear on the right and left.

Fig. 2 gives a view from above, with the same position of the parts, the lobes, however, projecting a little more, and the auricles crossing each other.

Fig. 3. A view of the same from below, corresponding, in the arrangement of these parts, to Fig. 2.

Fig. 4. A profile view of the animal in the same attitude as in Fig. 1, but with the lobes opening.

Fig. 5. A view from above, in the same position as that shown in Fig. 2, but with the lobes expanding in the direction of the auricles, so that the longitudinal diameter is less when compared to that in Fig. 2.

Fig. 6. A profile view in a position at right angles with that of Fig. 1 and 4; so that one of the lobes is in sight, with its broad outer surface, and the four auricles appear as projections in two pairs on the right and left.

Fig. 7. A view from above, in the position of Fig. 2 and 5; but the lobes are expanded, and the auricles are stretching in parallel directions.

Fig. 8 represents the same as seen from below, also in the same position as that shown in Fig. 3, but with the lobes open; so that the mouth is entirely uncovered.

Fig. 9 gives a view of a specimen in the same position as that shown in Fig. 7, the lobes, however, still more elongated; so that the longitudinal diameter of the animal exceeds by far the transverse diameter.

Fig. 10 represents the same from below.

On comparing all the figures in this plate, we have Fig. 1 and 4 in the same attitudes, differing only in the degree of expansion of the lobes. We have Fig. 2, 5, 7, and 9, views from above, differing, also, chiefly in the degree of expansion of the lobes. Fig. 3, 8, and 10 are views from below, facing the mouth, differing also in the degree of expansion of the lobes. While Fig. 6 represents a profile view, in a direction at right angles with that shown in Fig. 1 and 4.

Plate VII.

Enlarged figures of *Bolina alata*, in various attitudes.

Fig. 1. Corresponding to Fig. 1 of Plate VI.

Fig. 2. Corresponding to Fig. 4 of Plate VI.

Fig. 3. In the same attitude, the lobes still more expanded, and turned inside out.

Fig. 4. Corresponding to Fig 6 of Plate VI.

Fig. 5. A view from below, corresponding to Fig. 3 of Plate VI., the lobes, however, being farther open, so as to entirely uncover the mouth.

Fig. 6. Corresponding to Fig. 2 of Plate VI.

Fig. 7 gives an enlarged view of the horizontal chymiferous tubes, and their connection with the vertical funnel below the circumscribed area and the bulb of the eye-speck.

Plate VIII.

Fig. 1. A profile view of *Bolina alata*, in the same position as that given in Fig. 3 of Plate VII., but more elongated, and turned mouth upwards.

Fig. 2. A view of the main chymiferous cavity, to show its connection with the radiating tubes, the vertical funnel, and the tentacular apparatus.

Fig. 3. A highly magnified view of the vertical funnel and the bulb of the eye-speck, with the base of the radiating tubes.

Fig. 4. The base of the tentacular apparatus in its connection with the walls of the mouth; seen in profile.

Fig. 5. A similar view, the specimen, however, placed obliquely, to show the two parallel edges of the mouth.

Fig. 6. A view of the mouth from below, with the chymiferous tubes following its edge between the fissure of the mouth and the tentacular apparatus, and anastomosing with the chymiferous tube of the auricle.

Fig. 7. An enlarged view from above, corresponding to Fig. 7 of Plate VI.

Fig. 8. The auricles greatly enlarged, to show the prolongation of the chymiferous tubes, which wind their course along through the margin of the auricles, to form an anastomosis with the chymiferous tubes from the large lobe, and from the mouth.

Fig. 9. A general view of the main stems of all the chymiferous tubes, seen from above, where the horizontal radiating tubes are most prominent; the tubes of the tentacular apparatus and the walls of the cavity appearing upon the sides of the bulb of the eye-speck, and the tubes which encircle the mouth being seen faintly through the substance of the body.

APPENDIX.

FELLOWS

OF

THE AMERICAN ACADEMY

OF

ARTS AND SCIENCES.

I. RESIDENT IN MASSACHUSETTS.

A.

Joseph Hale Abbot, A. M., *Boston.*
Samuel Leonard Abbot, M. D., *Boston.*
Charles B. Adams, A. M., *Prof. Zoölogy, &c., Amherst College.*
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Francis Alger, A. M., *Boston.*
Rev. William Allen, D. D., *Ex-President of Bowdoin College, Northampton.*
Nathan Appleton, A. M., *Boston.*

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James F. Baldwin, *Boston.*
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Jacob Bigelow, M. D., *President Am. Acad., Prof. Mat. Med., Harv. Univ., Boston.*
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George P. Bond, A. B., *Cambridge.*
Simeon Borden, *Fall River.*
Thomas T. Bouvé, *Boston.*
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J. Ingersoll Bowditch, A. M., *Boston.*
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Caleb Cushing, LL. D., *Newburyport.*

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E. S. Dixwell, A. M., *Cambridge.*

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Benjamin A. Gould, Jr., P. D., *Cambridge.*
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Francis C. Gray, LL. D., *Boston.*
Horace Gray, A. M., *Roxbury.*
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Arnold Guyot, A. M., *Cambridge.*

H.

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Jonathan P. Hall, *Boston.*
Thaddeus William Harris, M. D., *Librarian of Harv. Univ., Cambridge.*
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Rev. Mark Hopkins, D. D. *President of Williams College, Williamstown.*
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Rev. Heman Humphrey, D. D., *Ex-President of Amherst College, Amherst.*

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L.

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John Amory Lowell, A. M., *Boston.*

M.

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Miss Maria Mitchell, *Nantucket, Honorary Member.*

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W.

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Jeffries Wyman, M. D., *Prof. Anat., Harv. Univ., Cambridge.*
Morrill Wyman, M. D., *Cambridge.*

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Elijah Paine, LL. D., *Williamstown.*

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George Engelmann, M. D., *St. Louis.*

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John C. Fremont.

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Robert Brown, D. C. L., LL. D., *London.*
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Francis Boott, M. D., *London.*
Very Rev. William Buckland, D. D., *Dean of Westminster.*
Michael Faraday, D. C. L., *London.*
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Sir John F. W. Herschel, Bart., D. C. L., *Collingwood, Kent.*
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Sir Roderick Impey Murchison, F. R. S., *London.*
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Rev. Wm. Whewell, D. D., *Master of Trinity College, Cambridge.*
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F. J. D. Arago, *Paris.*
Elie de Beaumont, *Paris.*
Jean Baptiste Biot, *Paris.*
A. L. Cauchy, *Paris.*
Joseph Decaisne, *Paris.*
Jean Baptiste Dumas, *Paris.*
Milne Edwards, *Paris.*
Jean Baptiste Benoit Eyries, *Paris.*
Benoit Fourneyron, *Paris.*
Adrien de Jussieu, *Paris.*
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P. C. A. Louis, *Paris.*
Edward de Verneuil, *Paris.*

SWITZERLAND.

Alphonse De Candolle, *Geneva.*

ITALY.

Nicola Cacciatore, *Palermo.*
Gino Capponi.
Domenico Lo Faso, *Palermo.*
Macedonie Melloni, *Naples.*
Horatio Greenough, *Florence.*
Giovanni Plana, *Turin.*

BELGIUM.

A. Quetelet, *Brussels.*
Th. Schwann, *Louvain.*

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Señor Pascual de Gayangos, *Madrid.*

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Christian Gottfried Ehrenberg, *Berlin.*
Johann Friedrich Encke, *Berlin.*
Karl Friedrich Gauss, *Göttingen.*
Peter Andreas Hansen, *Gotha.*
Alexander von Humboldt, *Berlin.*
Karl Gustav Jacob Jacobi, *Berlin.*
Justus von Liebig, *Giessen.*
Bernhard von Lindenau, *Altenburg.*
Karl Franz Philip von Martius, *Munich.*
Johannes Müller, *Berlin.*
Karl Ritter, *Berlin.*
Heinrich Rose, *Berlin.*
Heinrich Christian Schumacher, *Altona.*
Friedrich Tiedemann, *Heidelberg.*

DENMARK.

Jans Christian Œrsted, *Copenhagen.*

SWEDEN.

Elias Fries, *Upsal.*

RUSSIA.

Karl Ernst von Baer, *St. Petersburg.*
Charles Cramer, *St. Petersburg.*
Michael Ostrogradsky, *St. Petersburg.*
Friedrich Georg Wilhelm Struve, *Pulkowa.*
G. Fischer de Waldheim, *Moscow.*

STATUTES

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

CHAPTER I.

Of Officers.

1. THERE shall be a President, a Vice-President, a Corresponding Secretary, a Recording Secretary, a Treasurer, and a Librarian, which officers shall be annually elected, by written votes, the day next preceding the last Wednesday in May.

2. If either of the Secretaries, the Treasurer, or the Keeper of the Library die, resign, or be removed during the year, the vacant office or offices shall, at the next meeting of the Academy, be filled, by written votes, for the remainder of the year.

CHAPTER II.

Of the President.

1. It shall be the duty of the President, and, in his absence, of the Vice-President or next officer in order, as above enumerated, to preside at the meetings of the Academy; to summon extraordinary meetings of the Academy, upon any urgent occasion; and to execute or see to the execution of the statutes of the Academy.

2. The President, or in his absence the next officer as above enumerated, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct. Bills presented on account of the Library or the publications of the Academy must be previously approved by the respective committees on these departments.

3. The President, or in his absence the next officer as above enumerated, shall nominate members to serve on the different committees of the Academy.

4. Any deed or writing, to which the common seal is to be affixed, shall be signed and sealed by the President, when thereto authorized by the Academy.

CHAPTER III.

Of the Secretaries.

1. The Corresponding Secretary shall keep the letter-book, shall record all letters written in the name of the Academy, and preserve on file all letters which are received; and, at each meeting, he shall read such letters as have been addressed to the Academy since the last meeting. With the advice and consent of the President, he may propose and make exchanges with such other scientific associations as he shall deem proper, and may give copies of the Transactions of the Academy for this purpose.

2. The Recording Secretary shall have charge of the charter and statute-book, journals, and all literary papers belonging to the Academy. He shall keep a record of the proceedings of the Academy at its meetings, and, after each meeting is duly opened by the presiding officer, he shall read the proceedings of the last meeting. He shall post up in the Hall a list of the persons nominated for election into the Academy, which list shall remain there at least during the interval between two successive quarterly meetings; and when any individual is chosen, he shall insert in the records the names of the Fellows by whom he was nominated.

3. The Corresponding and Recording Secretaries shall have authority to publish in an octavo form such of the proceedings of the Academy as may seem to them calculated to advance the interests of science.

4. It shall be the duty of the Corresponding Secretary, with the advice and consent of the President, to distribute copies of the Memoirs to Fellows of the Academy residing in foreign countries, as they shall deem expedient.

5. Any Fellow of the Academy shall be entitled to receive one copy of each volume hereafter published, by applying personally, or by written order, for the same within two years after such publication.

CHAPTER IV.

Of the Treasurer.

1. The Treasurer shall give such security as the Academy may require, for the trust reposed in him.

2. The Treasurer shall receive officially all moneys or sums of money due or payable, and all bequests or donations made, to the Academy; and, by order of the President or presiding officer, shall pay such sums as the Academy shall direct; and shall keep an account of all receipts and expenditures.

3. All moneys or sums of money, which there shall not be present occasion to expend, shall be put out at interest on such securities, or otherwise disposed of, as the Academy shall direct.

4. The Treasurer shall keep a separate account of the income and appropriation of the Rumford Fund, and report the same annually.

5. The Treasurer's accounts shall be annually audited by a committee appointed by the Academy for the purpose; it being understood that the committee chosen at the annual meeting in May shall act for the year immediately following the date of their election.

CHAPTER V.

Of the Library and Cabinet.

1. It shall be the duty of the Librarian to take charge of the books, to keep a correct catalogue of the same, and to provide for the delivery of books from the Library.

2. Any Fellow of the Academy may have at any one time three volumes from the Library.

3. Books may be kept out three calendar months, and no longer; and every person shall be subjected to a fine of twenty cents a week for every volume retained beyond that time.

4. Every person who takes a book from the Library shall give a receipt for the same to the Librarian or his assistant.

5. Every book shall be returned in good order, regard being had to the necessary wear of the book with good usage. And if any book shall be lost or injured, the person to whom it stands charged shall replace it by a new volume or set, if it belong to a set, or pay the current price of the volume or set to the Librarian; and thereupon the remainder of the set, if the volume belonged to a set, shall be delivered to the person so paying for the same.

6. All books shall be returned to the Library for examination, at least one week before the annual meeting. And every person then having one or more books, and neglecting to return the same, as herein required, shall forfeit and pay a fine of one dollar.

7. A Committee on the Library, to consist of three persons, of whom the Librarian shall be one, shall be chosen at the annual meeting in May. This committee shall examine the Library, and make report of its condition at the next annual meeting. They shall have authority to purchase such books, from time to time, as they may deem expedient; to make rules and regulations concerning the circulation, return, and safe-keeping of the books; and to appoint such agents for these purposes as they may think necessary. And for all these objects there shall annually be appropriated a proper sum, to be expended under their direction, and the charges to be made either to the Rumford Fund, or to that of the Academy, as the committee may direct.

CHAPTER VI.

Of Meetings.

1. There shall be annually four stated meetings of the Academy, namely, on the last Wednesday in January, the day next preceding the last Wednesday in May, the second Wednesday in August, and the second Wednesday in November, to be held at the Hall of the Academy in Boston.

2. The President shall have power to call extraordinary meetings of the Academy, at such time and place as he shall see fit.

3. Seven Fellows shall constitute a quorum for the transaction of business of every description which may come before the Academy.

4. The Recording Secretary shall notify the meetings of the Academy to the Fellows residing in Boston and the vicinity, and shall also cause the meetings to be advertised in the public papers, whenever he deems such further notice to be necessary.

CHAPTER VII.

Of Fellows.

1. No person shall be elected a Fellow of the Academy, unless proposed and recommended by one or more Fellows, who shall subscribe their names to the recommendation upon the nomination list. The name shall stand on the nomination list at least during the interval between two statute meetings previous to the election. Three fourths of the votes given shall be necessary to constitute a majority for the admission of a member ; and when three fourths shall amount to less than seven, then seven votes shall be necessary. Should any person, on balloting, not be admitted, his name shall be removed from the nomination list ; but may at any future period be placed upon it again for a new nomination.

2. Each Fellow residing in the State of Massachusetts shall pay annually two dollars to the Academy, and such additional sum, not exceeding three dollars, as the Academy at its annual meeting shall require.

3. Foreign Honorary Members may be chosen by the same vote as Fellows : but only at the statute meetings of May and November, and from a nomination list prepared by a Council for that purpose, and publicly read at the meeting immediately preceding that on which the balloting takes place. The Council for nominating Foreign Members shall consist of the President, Vice-President, the Secretaries, Treasurer, Librarian, and the members of the three standing committees, and no candidate shall be balloted for who is not recommended by the signatures of two thirds of the members of the Council.

CHAPTER VIII.

On Literary Performances.

1. The Academy will never express its judgment on literary or scientific memoirs or performances submitted to it, or included in its printed transactions.

2. A committee of three persons, to be called the Committee on Publications, shall be chosen at each annual meeting, and to them all memoirs submitted to the Academy shall be referred.

CHAPTER IX.

On Amendments of the Statutes.

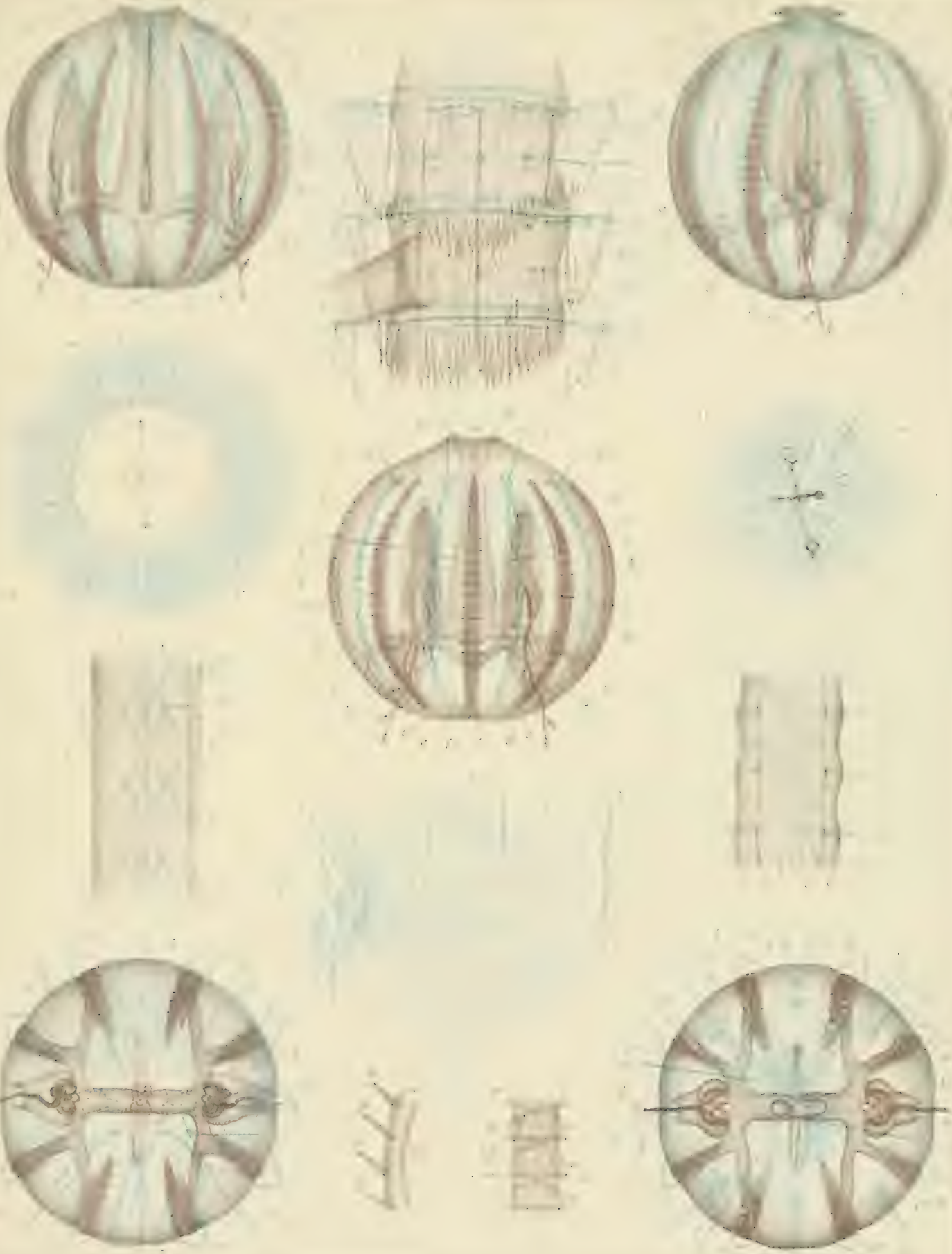
All proposed alterations or additions to the statutes shall be referred to a committee during the interval between two statute meetings, and shall require for enactment a majority of two thirds of the members present, and at least eighteen affirmative votes.

RUMFORD PREMIUM.

In conformity with the last will of Benjamin Count Rumford, granting a certain fund to the American Academy of Arts and Sciences, and of a decree of the Supreme Judicial Court for carrying into effect the general charitable intent and purpose of Count Rumford, as expressed in his said will, the Academy is empowered to make from the income of said fund, as it now exists, at any annual meeting, an award of a gold and silver medal, being together of the intrinsic value of three hundred dollars, as a premium, to the author of any important discovery or useful improvement on light or on heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America, or any of the American islands ; preference being always given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind ; and to add to such medals, as a further premium for such discoveries and improvement, if the Academy see fit so to do, a sum of money not exceeding three hundred dollars.

For this purpose, a standing committee is appointed annually by the Academy, in May, to consider and report on all applications for the Rumford Premium.

PLEUROB ACHI- RHOD DACTYL AGAS



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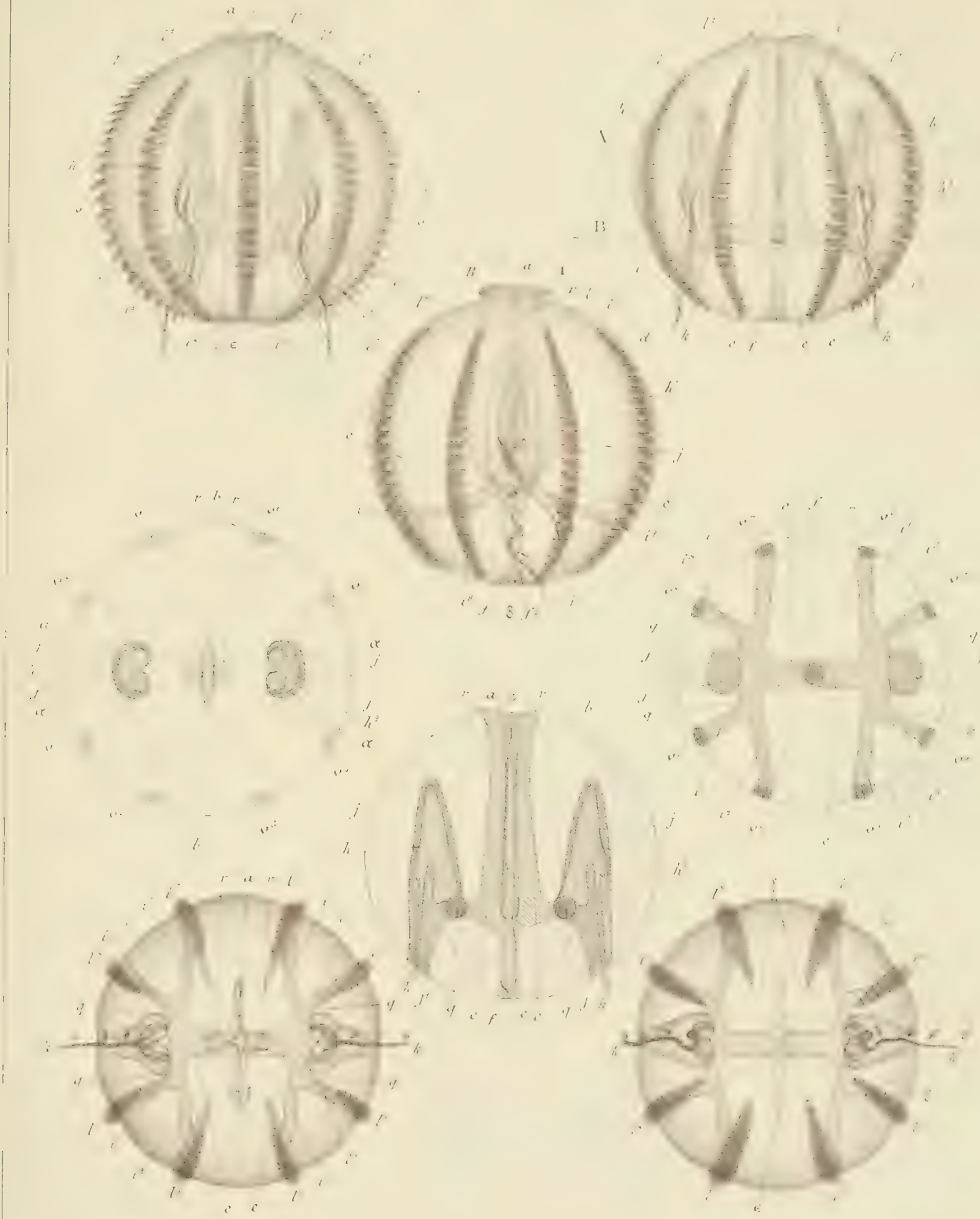
PLEUROBRACHIA RHODODACTYLA. AGASS.



A. Sonrel on stone from nat.

Tappan & Bradford's lith.

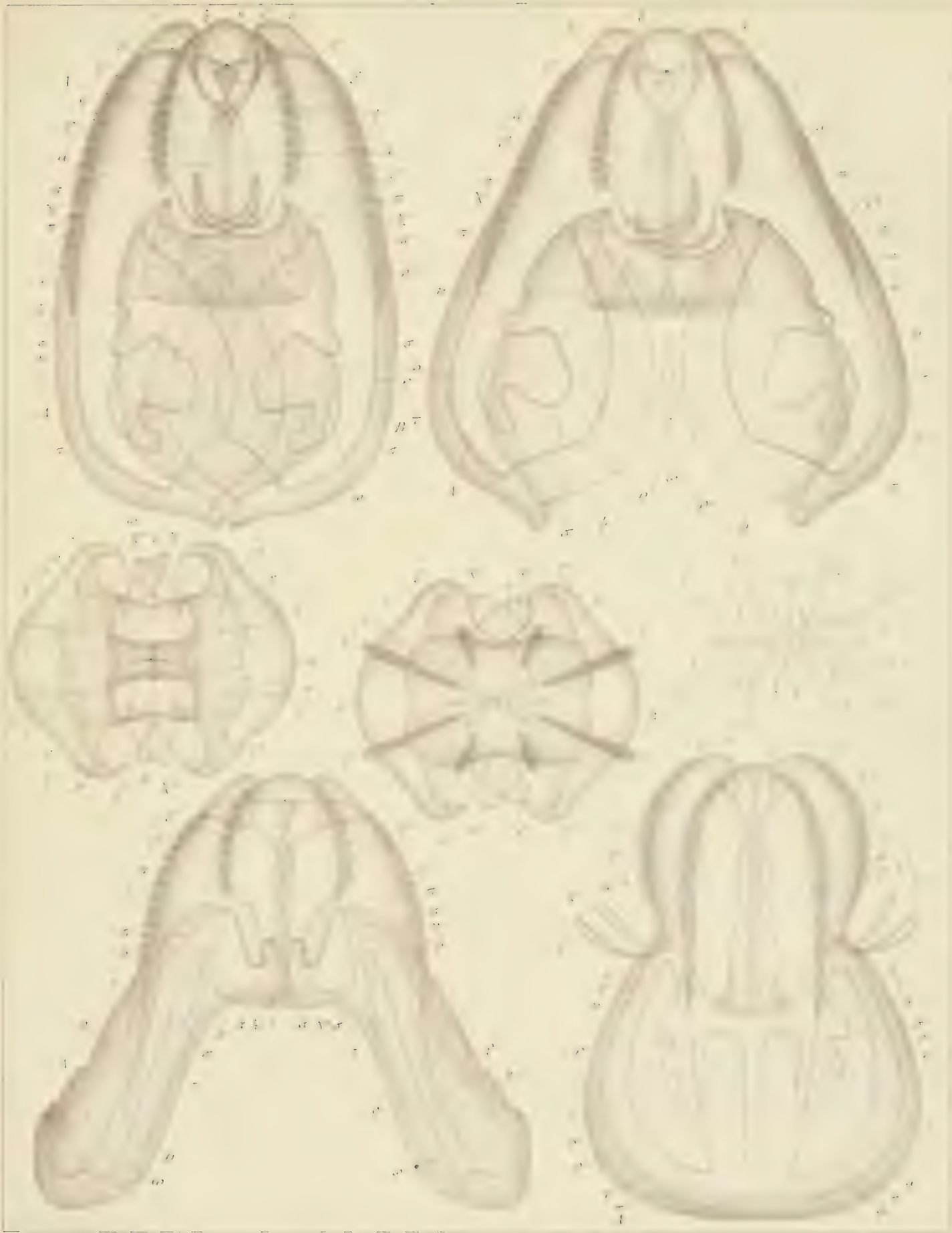
PLEUROBRACHIA RHODODACTYLA Agass.

A. Sonrel on stone.

Tappan & Bradford, lith.

PLEUROBRACHIA RHODODACTYLA Agass.

BOLINA ALATA Agass.



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